MAY
1959

PRICE $2.00

ELECTRICAL CONSTRUCTION AND MAINTENANCE

WITH ELECTRICAL CONTRACTING

an original engineering manual

MODERN ELECTRICAL SYSTEMS DESIGN

exclusive and complete in this issue

A McGRAW-HILL PUBLICATION | 58TH YEAR

NEW
GUTH KOLORKODED* industrial fixtures with built-in

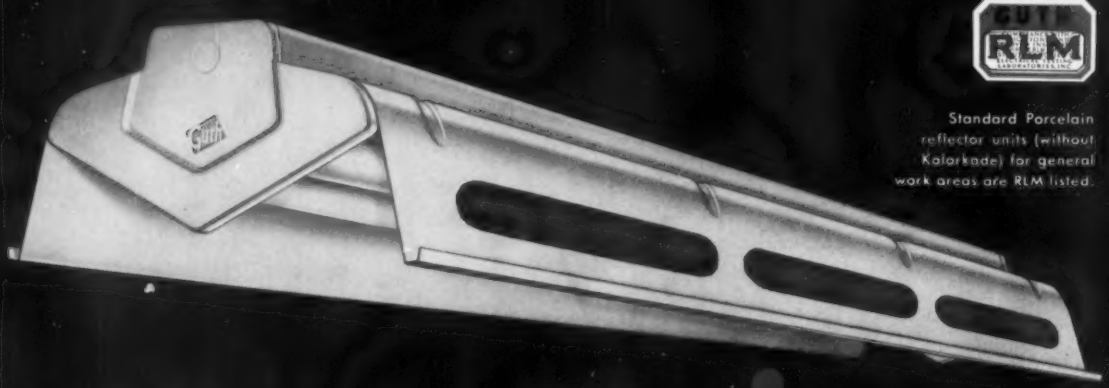
TRAFFIC LIGHTS

Designed to direct traffic, protect your workers, identify various plant or storage areas . . . and create new standards of seeing-efficiency for greater productivity.

They "wash away" ceiling shadows, yet assure high footcandles with comfortable shielding for the working level: 10% uplight with 13° cut-off or 25% uplight with 27° cut-off . . . for 430, 800 or 1500 M. A. operation. Easy installation and maintenance. Three reflector finishes—Permalux White, Porcelain or Alzak Aluminum.

WRITE FOR FREE KOLORKODED BULLETIN

*Copyright & U.S. & Can. Pats. applied for.



GUTH RLM

Standard Porcelain reflector units (without Kolorkode) for general work areas are RLM listed.

at exits, fire protection systems, keep-out areas, etc.

at stairs, curbs, dead ends and other hazard areas.

in aisles, safe storage, first-aid, etc.

Guth LIGHTING

THE EDWIN F. GUTH CO.
2615 Washington Blvd., St. Louis 3, Mo.
TRUSTED NAME IN LIGHTING SINCE 1902

Don't Price Yourself Out of the PLUS Features You Get with SQUARE D CONTROL CENTERS

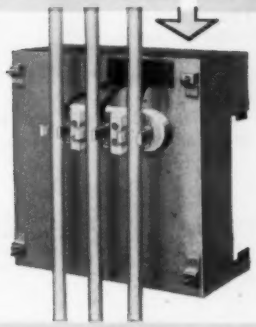
Industrial construction
All outer surfaces and structural parts are 12 gauge steel. Corner channels, cross members and doors are *formed* on special dies for maximum rigidity. Rust-resisting finish—phosphatized plus *baked* enamel.

Saves space
Unit heights in *3-inch* increments—an exclusive Square D advantage which permits use of units with minimum heights, eliminates the wasted space typical of modular systems.

Built-in safety
Units are metal-enclosed to confine damage should a fault occur. Unit side plates are permanently attached—can't be accidentally discarded. Switch-type units have visible blade disconnects for added safety.

Extra control flexibility
A variety of removable panels accommodates up to four oil-tight push buttons and pilot lights.

Tubular vertical buses
Another Square D "exclusive"—inherently stronger—greater cooling surface. Extra-wide spacing between phases gives added "breakdown" protection. Plug-in stabs are silver-plated copper backed by steel springs—give high pressure low resistance contact at all times.



Liberal wiring space
Wiring channels are *large and accessible*. No wire fishing through narrow passageways—wires can be laid in position—less costly installation.

GET THE COMPLETE STORY

BULLETIN SM-244 gives detailed information on all of the "plus" advantages you get when you specify Square D motor control centers. Send for a copy. Square D Company, 4041 North Richards St., Milwaukee 12, Wis.

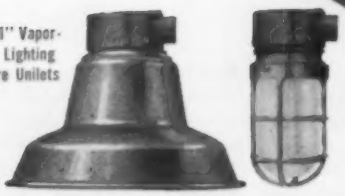
EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

For every need . . .

"AE" Plug and Receptacle Series Unilets

"AE" Series 30, 60, and 100 ampere plugs and receptacles come equipped with solderless connectors and replaceable interiors. Choice of lift cover, or threaded cap types.

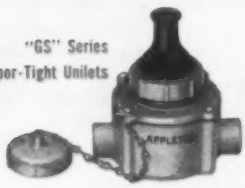


"V-51" Vapor-Tight Lighting Fixture Unilets

Vapor-tight lighting fixture series for use with rigid conduit. Known for its patented unit construction. Reflector and guard can be put on and taken off quickly . . . without tools! Designed for easy installation plus simple maintenance.

APPLETON®

Malleable Iron UNILETS®



"GS" Series Vapor-Tight Unilets

Full line of vapor-tight covers. Bodies with or without mounting lugs, and variety of hub arrangements. Excellent for use with vapor-tight fixtures, switches, plug and receptacle housings, etc.

One of the most complete selections in the industry!

Yes, APPLETON can supply you . . . with a wide variety of Unilets for receptacles, switches, plain junctions, pilot lights, fixture hangers, etc. Ample wiring room. Assorted hub arrangements. *You name it, we've got it* . . . for indoors or out.

And every APPLETON product is made to the rigid quality standards pioneered by APPLETON engineers. They are easy to wire, are blemish free, have clean, chamfered threads conforming to N.P.T. requirements assuring a tight joint and positive ground. Next time you buy, specify APPLETON!

"AL" Fixture Hanger Series Unilets

Two styles available . . . ball or cushion. Provides a perfectly aligned flexible suspension of electrical fixtures and allows a swivel to 20° in any direction.

"FS" and "FD" Series Unilets

Weather-proof housings for junctions, receptacles and switches . . . for use outdoors or in. One, two, three and four-gang styles.

Form 35 Series Unilets

Threaded and no-threaded malleable iron series . . . taper threads . . . covers held by screws — will not vibrate loose . . . high quality finish . . . full line.

"JB" Series Vapor-Tight Unilets

With or without mounting lugs. 4 tapped holes and 2 close-up plugs or blank body without close-up plugs. ½", ¾" and 1" sizes for use as "E", "C", "T", or "X" bodies.

Sold Through Franchised Distributors Only

APPLETON ELECTRIC COMPANY
1701 Wellington Avenue · Chicago 13, Illinois

APPLETON ELECTRIC PRODUCTS®

Also Manufacturers of:

Explosion-Proof Lighting Fixtures

"Eagle Claw" Outlet Boxes

"ST" Series Connectors

Roslites

ELECTRICAL CONSTRUCTION AND MAINTENANCE

with which is consolidated Electrical Contracting, The Electragist and Electrical Record . . . Established 1901

Published for electrical contractors, electrical departments in industry, engineers, consultants, inspectors and motor shops. Covering engineering, installation, repair, maintenance and management in the field of electrical construction and maintenance.

58TH YEAR • MAY 1959

Washington Report 5

Sidelights 8

Preface, *An Editorial* 111

Modern Electrical Design 113
An original engineering manual on practical design and layout.

- General Considerations 114
- Branch Circuits 120
- Distribution System 148
- Service Layout 181
- Residential Wiring 193
- Lighting Design 203
- Heating and Air Conditioning 235
- Signals and Communication 257

Reader Service 301
Product news announcements, catalogs and bulletins.

Reader's Quiz 320
Questions and answers on control circuits in conduit; dynamic braking and lowering; insects in conduit.

Questions on the Code 334
Answers to code questions including continuity over flexible conduit connectors; rating of disconnecting means; transformer vault construction.

In the News 350

Dates Ahead 366

W. T. STUART, *Editor*

Alice McMullen, *Managing Editor*

Associate Editors
Berlon C. Cooper, *New York*
August Eckel, *Chicago*
J. F. McPartland, *New York*
Hugh P. Scott, *San Francisco*

Assistant Editors
W. J. Martens, *Chicago*
W. J. Novak, *New York*

Art Editor
L. E. Devendorf, *New York*

Consulting Editors
Ray Ashley, *Chicago*
B. A. McDonald, *Rochester*
B. Z. Segall, *New Orleans*

Dexter Keezer, *Dir. Economic Staff*
George B. Bryant, Jr., *Chief Correspondent, Washington Bureau*
John Wilhelm, Editor, *World News*

W. W. GAREY, *Publisher*
A. L. DeWeerdt, *Circulation Manager*
W. C. Carmichael, *Business Manager*
Ann P. Barrett, *Production Manager*

C. B. Shaw, *Advertising Sales Manager*
A. B. Conklin, *New York*
E. P. Gardner, *New York*
A. E. French, Jr., *Philadelphia*
F. J. Seiler, *Cleveland*
R. A. Hubley, *Detroit*
Charles F. Minor, Jr., *Chicago*
R. R. Ream, *Chicago*
T. H. Carmody, R. C. Alcorn, *San Francisco*
F. E. Holland, *Dallas*
R. H. Antles, *Los Angeles*
R. H. Powell, *Atlanta*

Member of

AUDIT BUREAU OF CIRCULATIONS and ASSOCIATED BUSINESS PUBLICATIONS

Vol. 58, No. 5 May 1959

ELECTRICAL CONSTRUCTION and MAINTENANCE

Published monthly with an additional issue in September by McGraw-Hill Publishing Company, Inc. James H. McGraw (1860-1948), Founder. Executive, Editorial, Circulation and Advertising Offices: **McGraw-Hill Building, 330 W. 42nd St., New York 36, N. Y.** See panel right for directions regarding subscriptions or change of address. Publication Office, 99-129 North Broadway, Albany 1, N. Y. Officers of the McGraw-Hill Publishing Co., Inc.: Donald C. McGraw, President; Joseph A. Gerardi, Executive Vice-President; L. Keith Goodrich, Vice-President and Treasurer; John J. Cooke, Secretary; Officers of the Publications Division: Nelson L. Bond, President; Shelton Fisher, Senior Vice-President; Ralph B. Smith, Vice-President and Editorial Director; Joseph H. Allen, Vice-President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator.

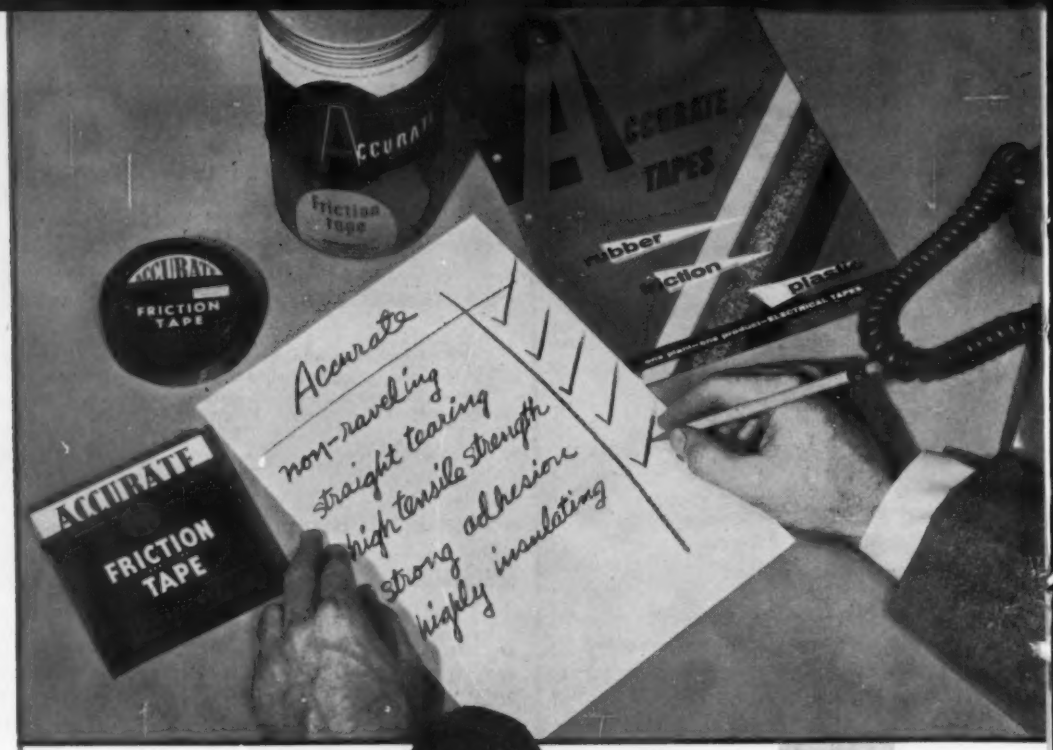
Subscriptions are solicited only from persons engaged in electrical construction, maintenance or consulting services. **Position and company connection must be indicated on subscription orders.**

United States subscription rate for individuals in the field of the publication $3.00 per year. This issue $2.00. Electrical Products Guide $2.50. Canada, $5.00 a year. All other countries, $15.00 a year, payable in advance. Second class postage paid at Albany, N. Y. Printed in U. S. A. Title registered in U.S. Patent Office.

©Copyrighted 1959 by McGraw-Hill Publishing Co., Inc. — All Rights Reserved.

SUBSCRIPTIONS: Send subscription correspondence and change of address to Subscription Manager, Electrical Construction and Maintenance, 330 West 42nd Street, New York 36, N. Y. Subscribers should notify Subscription Manager promptly of any change of address, giving old as well as new address, and including postal zone number, if any. If possible, enclose an address label from a recent issue of the magazine. Please allow one month for change to become effective.

Postmaster . . . Please send form 3579 to Electrical Construction and Maintenance, 330 West 42nd St., New York 36, N. Y.



They both know the best buy in tape . . .

ACCURATE TAPES

FRICTION . . . . RUBBER . . . . PLASTIC

Send for our latest catalog describing details

ACCURATE MANUFACTURING COMPANY
Garfield, New Jersey

Washington Report

MAY • 1959

Industrial output set a new record in March when the Federal Reserve Board's index rose 2 points to 147% (of 1947-49 average)—up 2 points from the pre-recession high of 145% in August 1957, and one point above the previous record of 146% in February 1957. Government economists predict a continuation of the upward production trend through this quarter, but expect some slowing down of economic activity in the 3rd quarter. Increased activity in steel and other commodities throughout this quarter, in protection against a possible steel strike in July, and subsequent price increases, will probably taper off, they believe. But record income and growing consumer demand, it is recognized, may outweigh slowdowns in hard goods production and inventories, keep economic activity moving upwards.

Building construction continues to forge ahead, will probably set a new 2nd-quarter record of some $13.3 billion. That would compare with under $12 billion for the same quarter last year, $12.3 billion in 1957. Total value of new construction in this year's first quarter was a record $10.9 billion, and for March was $3.8 billion compared with $3.3 billion for March last year.

Housing will be the biggest single contributing influence to construction's 2nd-quarter record. Value of housing for this period is expected to total about $5 billion. This compares with $4.2 billion for this period last year.

Housing starts in March totaled 117,000, a gain of 29,100 from February, for a seasonally-adjusted annual rate of 1,390,000. The March starts were nearly 40,000 above the 77,300 for March of last year.

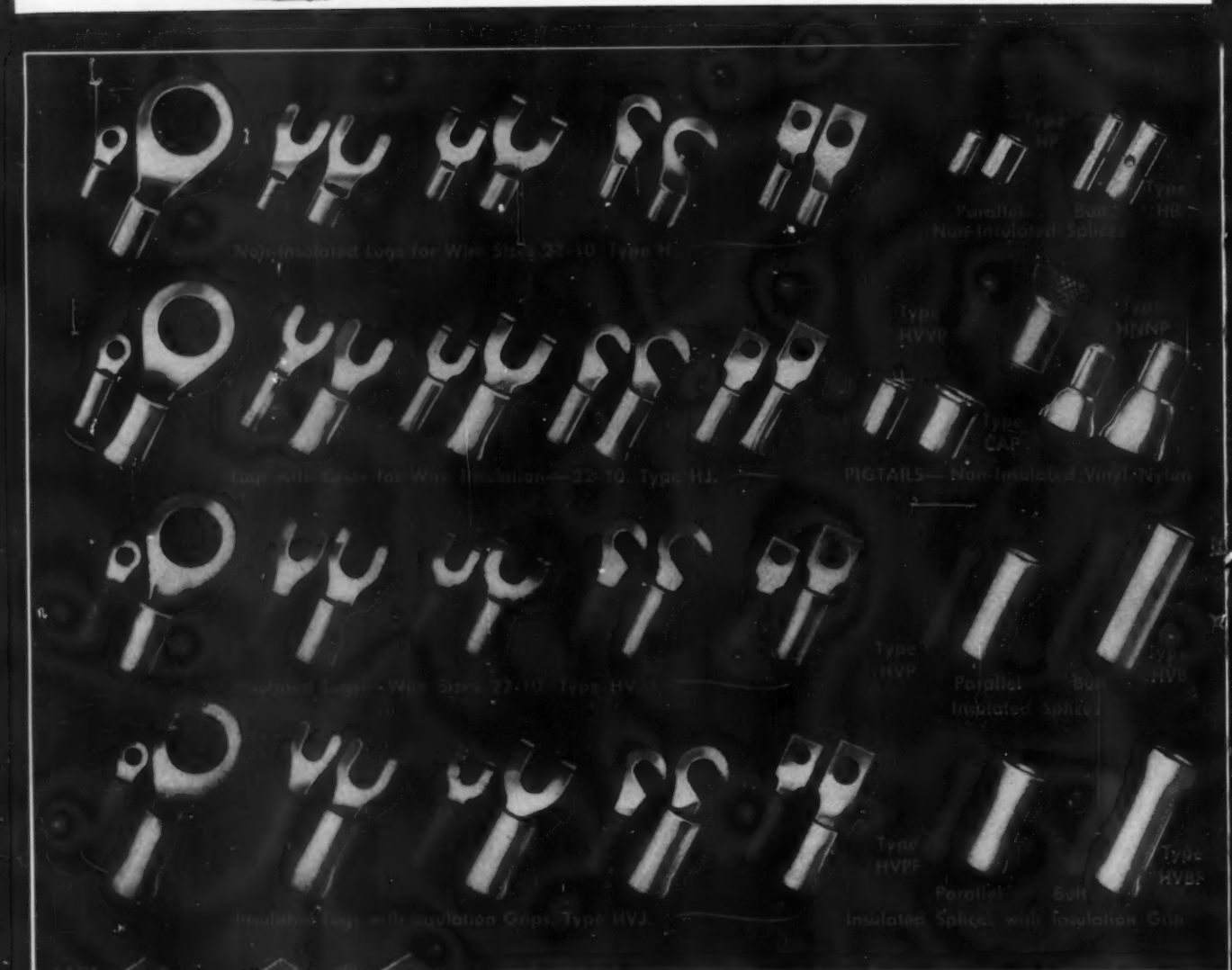
Financing of housing for this year is estimated to break down as percentage of units started about as follows: conventionally—60%; FHA—25%; VA—10%; and government—5%.

Other construction highlights: new contracts for industrial building are running about 25% ahead of a year ago; about 900 new shopping centers will be opened this year, compared with 300 last year, and 300 in 1957; bantam markets (small supermarket-type stores located for customer convenience) are growing in numbers—nearly 700 already exist, 300 more will open this year.

Two thermoelectric generators have been ordered by U. S. Navy Bureau of Ships. These units will transform heat directly into electricity, will have no moving parts, will be practically noiseless and vibrationless—and the first to be built on other than an experimental basis.

Big 80-passenger mobile lounges will ferry jet plane passengers between terminal buildings and planes at new International Airport at Chantilly, Va., 35 minutes from downtown Washington, D. C. Airlines and Federal Aviation Agency agreed to use of these "people pods" to save construction of two miles of octopus-like causeways leading from terminal to arrival and departure gates.

Gross national product (GNP) hit a record annual rate of $464 billion during 1st quarter of this year, government economists reported. This is a $11 billion gain over 4th quarter of 1958, and compares with a total of $437.7 billion for 1958 as a whole. Recent estimates point to a record $470 billion total for 1959, with the 2nd quarter hitting a record of about $475 billion.



ONE Color-Coded Tool
for BOTH
Insulated and Non-Insulated
Penn-Crimps—22 to 10

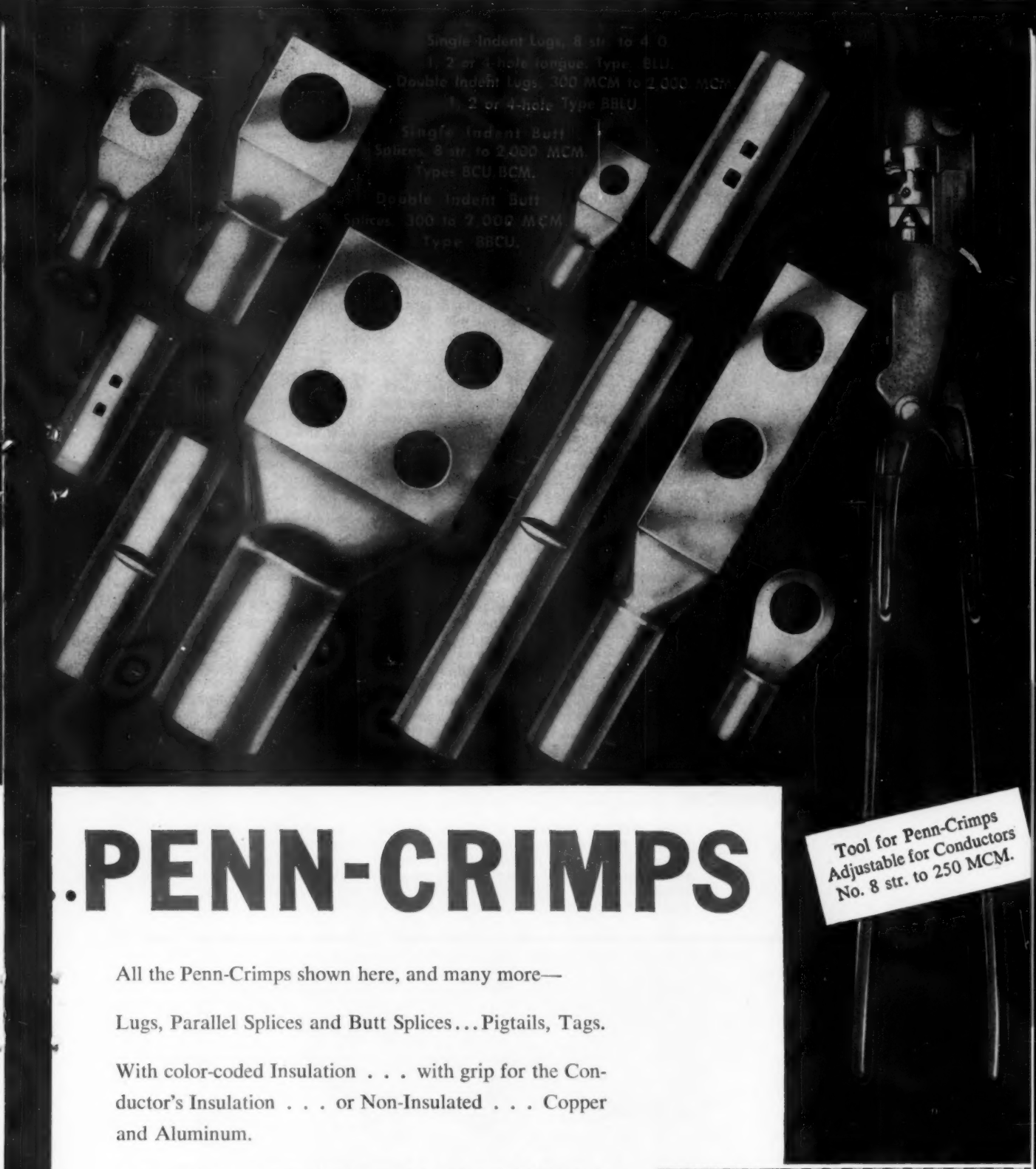
The *Complete* line···

SLIDE-TOP BOX. Spout opens instantly—on one side—at a touch on the slide.
Top is never off. Doesn't spill lugs if it's dropped.

The Connectors on both pages are ACTUAL SIZE—there was not room to show the largest (up to 2,000 MCM).
Tool for large Penn-Crimps shown ⅓ actual size.
Tool for 22-10 Penn-Crimps shown ½ actual size.

HAVE YOU A CONNECTOR PROBLEM?
Special Designs and Sizes can be furnished.

PENN-UNION
a good connection


Single Indent Lugs, 8 str. to 4/0
1, 2 or 4-hole tongue. Type BLU.
Double Indent Lugs, 300 MCM to 2,000 MCM
1, 2 or 4-hole Type BBLU
Single Indent Butt Splices, 8 str. to 2,000 MCM. Types BCU, BCM.
Double Indent Butt Splices, 300 to 2,000 MCM. Type BBCU.

PENN-CRIMPS

Tool for Penn-Crimps Adjustable for Conductors No. 8 str. to 250 MCM.

All the Penn-Crimps shown here, and many more—

Lugs, Parallel Splices and Butt Splices... Pigtails, Tags.

With color-coded Insulation . . . with grip for the Conductor's Insulation . . . or Non-Insulated . . . Copper and Aluminum.

The complete range for conductors No. 22 to 2,000 MCM.

Mail the coupon for Catalog—or Samples of the types you use most.

PENN-UNION ELECTRIC CORPORATION, Erie, Pa.

Export Sales—Philips Export Co., Division of North American Philips Co., Inc.
100 East 42nd. St., New York 17, N. Y. Cable Address "Philyork"

Penn-Union Electric Corp., Erie, Pa.

Please send Catalog of the complete line of Penn-Crimps.

Send samples of _____

type, in _____ sizes.

(Name) _____

(Company Name) _____

(Address) _____

IF YOU CAN'T "BEAR" BATHROOM ODORS & MOISTURE FOG

Sidelights

A RECORD

This is the largest single issue of *Electrical Construction and Maintenance* in its almost 58 years of service to the industry. It contains the biggest single editorial project we have ever compiled; a comprehensive book-length, engineering manual on "Modern Electrical Systems Design." In some aspects this is a revision of a similar project originally published in our May 1956 issue. However, much of the text and all of the illustrations are entirely new. A limited number of extra copies will be available at $2.00 each. A hard-cover book edition is in negotiation and will probably be available later in the year.

TOOLS AND METHODS

Coming in our big July issue is a special report on up-to-date electrical construction, installation and maintenance job methods and tooling practice. The extensive roundup is the result of many suggestions and inquiries from our readers who want to know how their own tool inventory and job methods measure up to current activities in other areas. The editorial project has been developed in the capable hands of Associate Editor August Eckel and will be packed with practical, job tested ideas.

TRY YOUR HAND AT WRITING

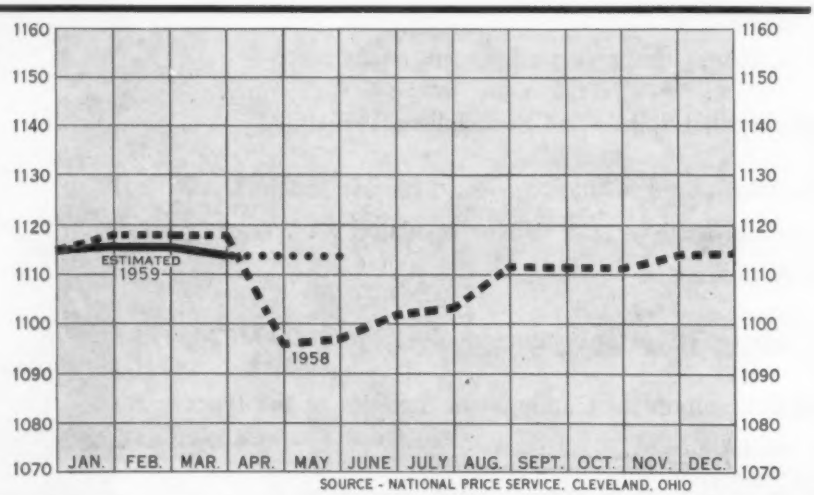
While the greater part of the editorial contents of this publication is prepared and written by our own staff, from time to time we receive excellent feature articles and short items written by readers. These are quite welcome and we usually encourage readers to try their hands at writing for publication. Any time you are involved in a job which you find challenging and interesting, the chances are a concise description of the work would be equally interesting to other electrical men with similar responsibilities. Write it up. Take some pictures. Attach a drawing or sketch and send it to us. If it is acceptable and we publish it, you will receive an appropriate payment. The intangible rewards are also substantial. Authorship of published articles adds significantly to your own and your company's prestige in the industry. For those who might want to know more about the arts and procedures of writing for publication, we commend a new book "Successful Technical Writing" by Tyler G. Hicks, McGraw-Hill Book Co., $5.50, as a very practical guide.

BIDDING WITHOUT GUESSWORK

Good bidding practice is closely related to sound administrative procedures from customer contact to bill collecting. Beginning next month, Rowan C. Brooks, Rapid Electric Service, Glendale, Calif., gives some pertinent answers to many tough questions about bidding practice in a two-part article, "Bidding Doesn't Have to be Guesswork." The articles deal particularly with the problems of smaller contractors.

ELECTRICAL MATERIALS COST INDEX

BASE LINE (1000) REPRESENTS COSTS OF TYPICAL ASSORTMENT OF MATERIALS FOR A SELECTED JOB AS OF NOVEMBER 1, 1951. INDEX POINTS REPRESENT THE VARIATION OF THESE SAME MATERIAL COSTS AS OF THE FIRST OF EACH MONTH.



SOURCE - NATIONAL PRICE SERVICE, CLEVELAND, OHIO

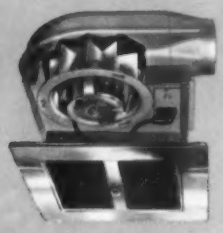
IF YOU CAN'T "BEAR" BATHROOM ODORS & MOISTURE FOG

NuTone Bathroom Fans

KEEP AIR FRESH, ODOR-FREE & MOISTURE-FREE

No matter whether your bathrooms are "inside plan"..or "outside wall"..you need exhaust fans to avoid lingering odors and prevent damage of steam and moisture to walls. NuTone offers 3 basic types of bathroom fans, designed especially for odor-free and moisture-free bathrooms.

U. S. and Foreign Patents



LESS THAN 4" THIN!

↑ Model 883 Bathroom Fan. **For Wall or Ceiling use. Blower fan fits between standard 2 x 4 wall studs or installation between ceiling joists. Transition allows 3" duct for 4" wall cap. Equipped with a built-in back draft damper. Only $23.95 list.**

FREE CATALOGS & INSTALLATION DATA

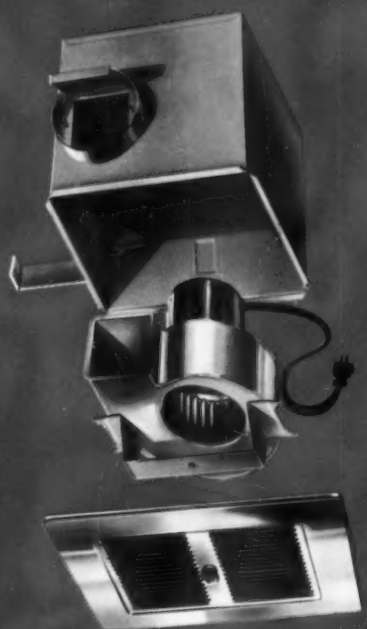
•

Write NUTONE, INC.

Dept. EC-5

Cincinnati 27, Ohio

BLOWER TYPE EXHAUST FAN



EXHAUST FAN PLUS LIGHT

↑ Model 866 Vent-A-Lite. **An exhaust fan plus overhead lighting, both for the cost of one combination unit. Fan blower is quiet and moves just the right amount of air without drafts. Provides better lighting to cover the entire bathroom area. Motor guaranteed 5 years. $36.95.**

← Model 881 Bathroom Fan. **Especially effective for bathroom use, where closed doors require a fan with high static pull. Can be discharged into attic space of a single floor plan or between joists in two-floor plan. Duct 4" diameter. 100 CFM. Anodized aluminum grille. Enclosed motor is moisture resistant. $25.95 list.**

SEE OTHER SIDE

WHY SHIVER IN THE BATHROOM . . . LIKE A "COOL-CAT"?

NuTone Ceiling Heaters

FOR INSTANT HEAT ON CHILLY MORNINGS OR OFF SEASONS

There are many months when bathrooms are far too chilly for comfort or good health. Even in homes with central heating . . auxiliary heat is needed early in the morning after the furnace has been turned down during the night, or for "off-season chill" . . or to help dry the hair.

HEATER PLUS LIGHT

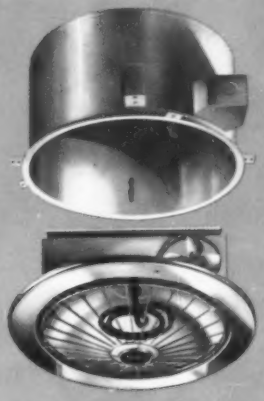
← Model 901 Heat-A-Lite. **Circulating heat plus light. Recirculating fan forces air downward, prevents heat loss. 1475 watts. $49.95 list.**

SURFACE-MOUNTED IN CEILING

↑ Model 928 Radiant Heater. **It's surface mounted . . only 9" high. Mounts like a standard lighting fixture. Heats 2 ways . . with direct heat and reflected heat. Enclosed heating element, 1,000 watts. No extra heat bulbs or elements needed. Only $18.95 list.**

U. S. and Foreign Patents

CEILING HEATER PLUS FAN PLUS LIGHT



RADIANT CEILING HEATER

↑ Model 920 Built-In Radiant Heater. **Instant, infra-red heat spreads its relaxing warmth throughout the bathroom. Especially designed arc reflects balanced heat. 1,000 watts. $26.95 list.**

← Model 909-11 Heat-A-VentLite. **Three bathroom conveniences for the price of one . . a heater plus an exhaust fan plus a light. The only ceiling fixture of its kind with two blades . . propeller for circulating warm air and blower wheel to exhaust odors and steam. Enclosed heating element. 1475 watts to 1800 watts. $64.95 to $69.95 list.**

FREE CATALOGS & INSTALLATION DATA

•

Write NUTONE, INC.

Dept. EC-5

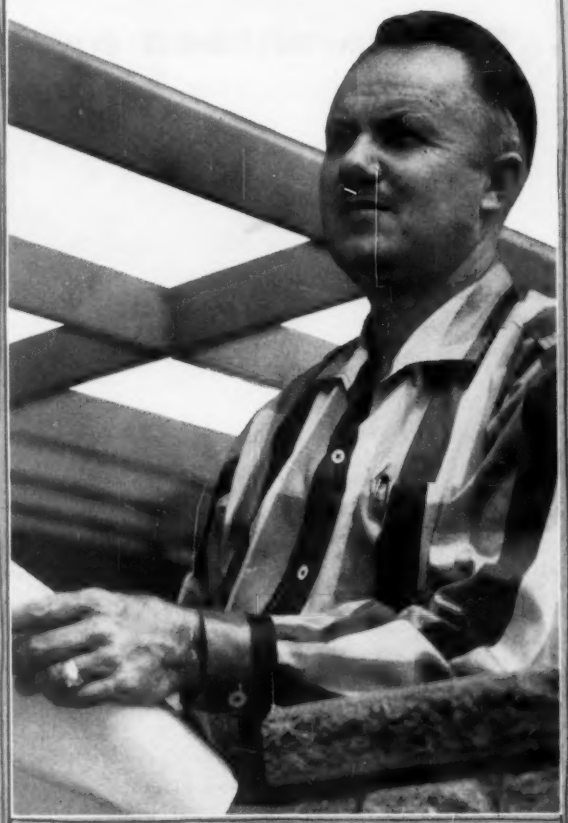
Cincinnati 27, Ohio

SEE OTHER SIDE

Specify

"New homes aren't really up-to-date without concealed telephone wiring"

**—SAYS BURTON W. DUENKE,
CUSTOM BUILDER OF ST. LOUIS, MISSOURI**



"Nowadays," says Mr. Duenke, "it's *ideas* that sell homes. The modern house-hunter is looking for more than a roof over his head and X number of bedrooms and closets. He wants smart, functional design —and proof that the house is planned to meet his future needs. Concealed telephone wiring is the kind of idea he likes."

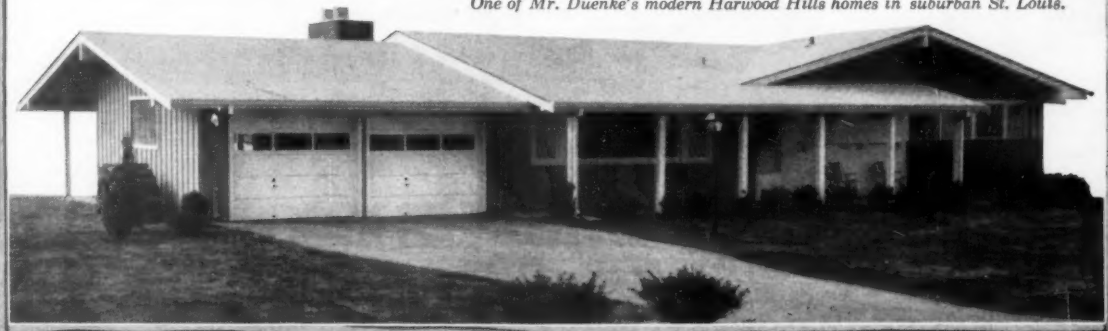
The Burton W. Duenke Building Company has completed over 1000 homes since 1947. Its current project is Harwood Hills, a gracious community of homes in the $26,000 to $40,000 price range, located in suburban St. Louis, to the west. Every one of these modern dwellings features *six* or *seven* concealed telephone outlets.

"We don't look on concealed telephone wiring as a luxury item," says Mr. Duenke. "It's a necessity in doing a workmanlike job of building today's home. It provides for the homeowner's future telephone needs, and keeps his home more attractive. What's more, it's a kind of sales feature that costs us very little to offer."

Your local Telephone Business Office will gladly help you with telephone planning for your homes. For details on home telephone installations, see Sweet's Light Construction File, 8i/Be. For commercial installations, Sweet's Architectural File, 32a/Be.

BELL TELEPHONE SYSTEM

One of Mr. Duenke's modern Harwood Hills homes in suburban St. Louis.



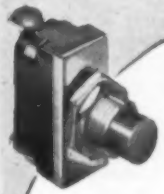
Specify McGILL® *Levolier*® switches

...for guaranteed precision plus durability

The high standards of design, craftsmanship and material selection make it possible to guarantee No. 41 LEVOLIER switch unconditionally against failure in lighting circuits. This extra quality is reflected in the performance of all LEVOLIER switches.

It pays to specify the best to avoid frequent and costly replacement. LEVOLIER canopy, toggle, push button and momentary contact switches easily withstand the hard use and abuse of industrial service. All are Underwriters' Laboratories inspected.

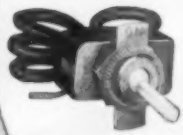
UNCONDITIONALLY GUARANTEED No. 41 single-pole, single-circuit, universal lever switch 6 amp. "T" 125V—3 amp. 250V. Only 5/8" thick, it is ideal for conduit box and canopy mounting for lighting and FHP motor control.



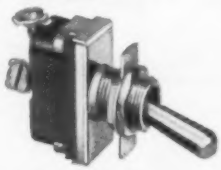
No. 100 single-pole, 15 amp. 125-250V, 1 HP 120-240V AC, normally "OFF" momentary contact switch. 1 amp., 125V—1/2 amp., 250V DC. Especially suitable for limit and safety control of industrial machinery.

No. 29 single-circuit, .75 amp., 125V, normally "ON" momentary contact switch. Excellent for automatic control of lights as in door openings and closings.

No. 71 single-pole, single circuit, universal lever switch . . . the thinnest 6 amp. "T" 125V—3 amp. 250V switch of its kind on the market today—only 15/32" thick. Also with push button.



No. 25 toggle switch carries a 6 amp. "T" 125V, 3 amp., 250V rating with an S.P.S.T. double-break mechanism. 1/3 HP AC 120-240V. Ideal for panel board, FHP motors, appliances, power tools, etc.



No. 90 3/4 HP capacity, 15 amp. 125V, 10 amp. 250V toggle switch with an S.P.S.T. mechanism. Designed for AC operation. Also carries 20 amp. 125V AC non-inductive load for heater applications. Also available in two circuit with center off and no off. Choice of terminals.

For complete descriptions of the entire McGILL line of switches, sockets, portable lampguards and other electrical specialties, write for catalog No. 84.

AVAILABLE FROM YOUR ELECTRICAL WHOLESALER

engineered electrical products

McGILL®

precision needle roller bearings

McGILL MANUFACTURING COMPANY, INC., ELECTRICAL DIV., 450 N. CAMPBELL ST., VALPARAISO, INDIANA

ALLIS-CHALMERS

"Profit Line for '59"
Electrical Products from **ALLIS-CHALMERS**

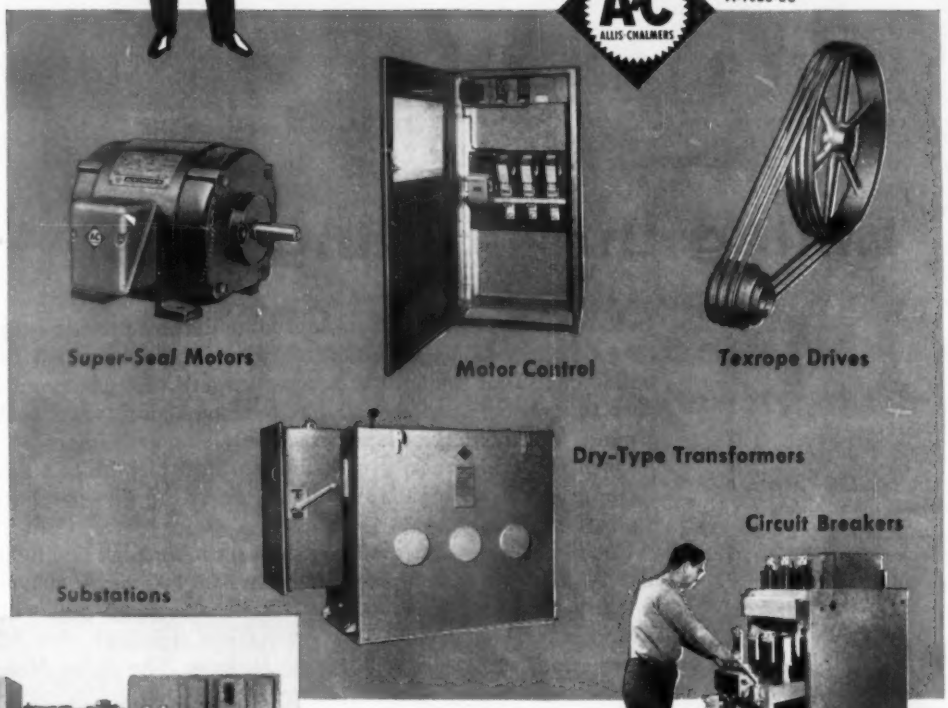
ONE MAN can provide ALL this equipment

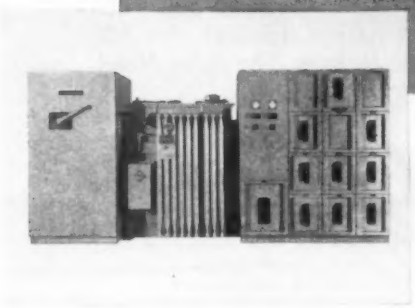
He's your Allis-Chalmers representative. *One inquiry* to him and much of the equipment you need for any electrical construction job is available.

Time and Money Savings for Extra Profits — because a single, dependable source means "unit responsibility" for deliveries, installation help, fast parts service. And, once installed, this equipment continues to be backed by outstanding field service — without "buck passing."

Ask "The Man" about the profitable A-C products for electrical construction. *Or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wis.*

A-C ALLIS-CHALMERS A-1028-EC

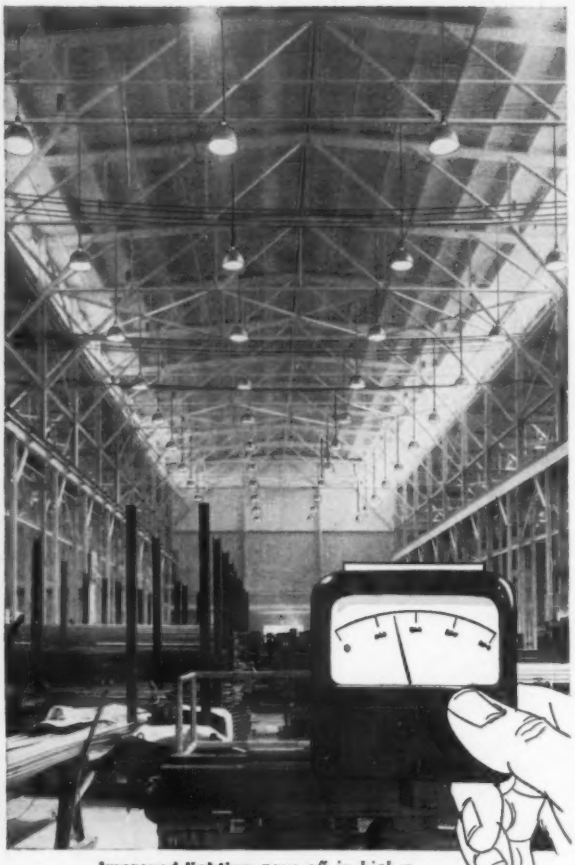




ALLIS-CHALMERS

Super-Seal and *Texrope* are Allis-Chalmers trademarks.

Dull, dreary lighting *cuts down worker efficiency, causes eye strain, makes many work tasks hazardous.*



Improved lighting *pays off in higher output and greater accuracy, comfort and safety for workers.*

Lifting the lighting level

In the picture on the right, those Abolite fixtures provide a high level of comfortable, glareless light throughout this high bay building. 18% of the light is directed upward through Abolite's open top, washes out the deep shadows, gives lamps a soft background. 35° shielding of lamp practically eliminates glare.

Open-top design also gives Abolite high bay units a self-cleaning action. Air circulates through the fixture, sweeps reflecting surface clean.

Choose from several Abolite uplight units for high bay lighting: 18" and 24" Alzak aluminum fixtures for 400 and 1000 watt mercury lamps; and 14" and 18" fixtures for 300-500 watt incandescent lamps (ideal for gymnasium lighting). For full information, write *Abolite Lighting Division, The Jones Metal Products Company, West Lafayette, Ohio.*

Abolite Cat. No. HMFAU-2400 Alzak aluminum uplight fixtures with 400 watt white reflector Mercury lamps.

eye-fi RE/LIGHTING

ABOLITE Lighting

THE JONES METAL PRODUCTS COMPANY

West Lafayette, Ohio

ALLIS-CHALMERS

In pace with POWER... ALLIS-CHALMERS

ALLIS-CHALMERS

Low cost, high speed 4.16-kv oilless units replace obsolete under-capacity breakers

Eliminate a fire hazard, reduce maintenance, provide modern high speed interruption, plus adequate interrupting and continuous-current capacity with Allis-Chalmers replacement breakers.

Existing cables and structures can be used with these replacement breakers. Low cost modernization can thus be provided in power-generating and substation facilities. The air magnetic breaker, together with its sturdy metal enclosure, can be installed in the masonry cell or open-type iron pipe framework previously occupied by the obsolete oil circuit breaker. Buswork, disconnect switches, current transformers, and cables can all be retained because of low height.

Modern features of breaker include: 5-cycle interruption, flame-retardent insulation, safety interlocks, full steel floor in breaker compartment, automatic shutters, one man disassembly. Interrupting capacities from 75,000 to 250,000 kva available.

For details contact your nearby A-C office or Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

A-C ALLIS-CHALMERS

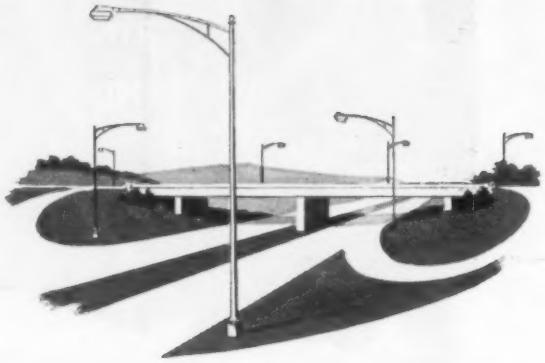
A-5977-PR

for street lighting • highway lighting • floodlighting

UNION METAL MONOTUBE POLES

Monotube street lighting poles . . . steel or aluminum . . . round or fluted . . . davit or bracket styling . . . anchor or transformer base. Attractive in any location. Continuous-tapered Monotube poles are available in a broad range of designs and sizes to meet all requirements.

Monotube highway lighting poles are offered for various mounting heights and strength requirements. Easily wired and installed. Steel Monotubes are made from high grade, open hearth steel and cold-rolled for strength. Aluminum poles are made by the spinning method.



Monotube floodlighting poles . . . for sports, business, industrial or recreational areas. Available in heights from 20 to 100 feet. Monotube designs permit extreme flexibility in arrangement and number of light units per pole. Floodlights can be mounted, positioned and wired while pole is on the ground.

LIVE BETTER ELECTRICALLY

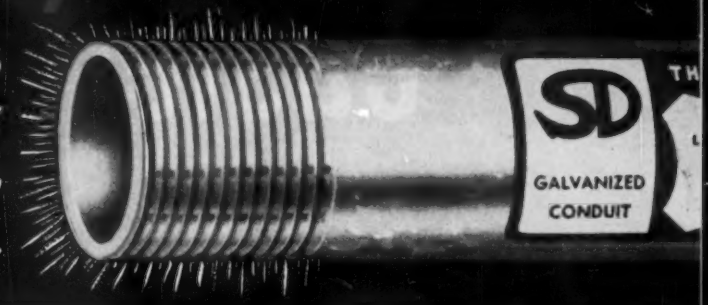
THE **UNION METAL** MANUFACTURING COMPANY

CANTON 5, OHIO — BRAMPTON, ONTARIO, CANADA

Monotube Lighting Poles

NOW UNIFORM GALVANIZED THREADS by STEELDUCT

CUTS INSTALLATION COSTS BY ELIMINATING RUSTY THREADS AND ASSURING FREE RUNNING COUPLINGS.



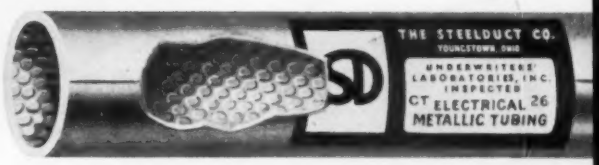
OTHER STEELDUCT FEATURES THAT SAVE TIME AND CUT LABOR COSTS

DOUBLE THREAD PROTECTION

As the zinc protects the sharp, clean Steelduct threads from corrosion, Steelduct plastic and fiber-metal caps protect the threads from damage in rough shipping and storage conditions. Protectors are color coded for easy size identification.

KNURLED — NO WELD BEAD

New enamel plus knurled inner surface and beadless weld of EMT reduces pulling effort 37%. Wiremen bend Steelduct Bend-Aliner EMT to any degree without splitting continuous welded seam.



Steelduct Conduit Meets Federal and ASA Specifications

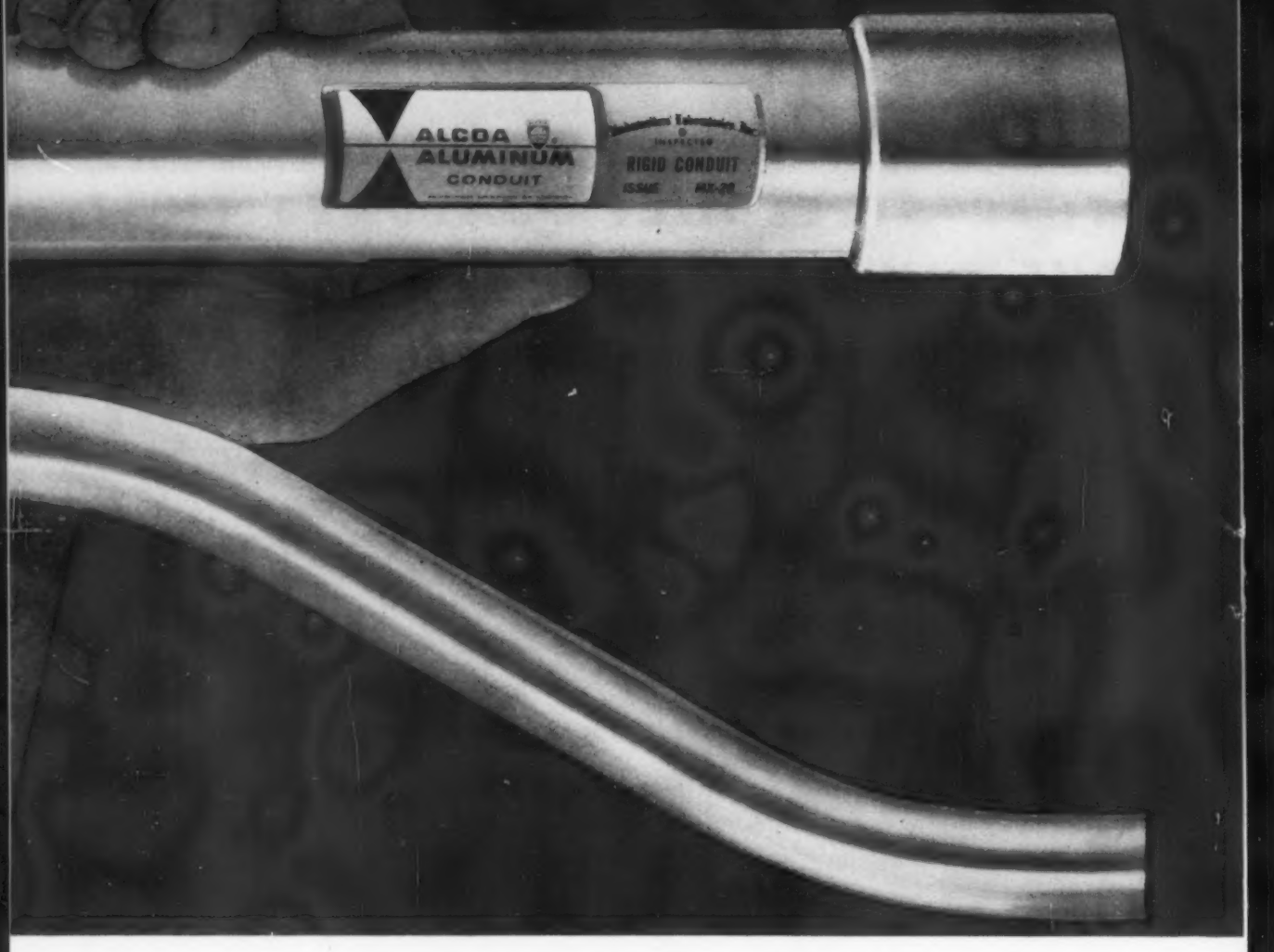
THE STEELDUCT COMPANY

REPUBLIC STEEL BUILDING — YOUNGSTOWN, OHIO

ALCOA ALUMINUM CONDUIT...

easier to handle,

easier to install,



easier to cut, bend, thread

The choice is easy with three big reasons like these to back you up. Yes, Alcoa® Aluminum Electrical Rigid Conduit not only makes the job easier, but also provides a higher quality, longer lasting installation. More and more contractors and engineers are selecting Alcoa Conduit for a wide array of applications, industrial and commercial, even residential. Here's why:

1. Easier to lift, load, carry, erect and therefore more economical handling from start to finish—Alcoa Conduit weighs only one-third as much as conventional rigid conduit.
2. Alcoa Conduit is easier to cut, bend, thread . . . faster, too.
3. Wirepulling is easy—Alcoa Conduit is specially lubricated at the factory.
4. Selection of sizes is simple with Alcoa color-coded thread protectors.
5. Alcoa Conduit is competitive in price.

ALCOA CONDUIT ALSO OFFERS YOU...

1. Lower installed cost—this has been proved . . . is being proved over and over by cost- and quality-conscious contractors and engineers everywhere.
2. Longer life, less maintenance—Alcoa Conduit is corrosion resistant through and through, needs no painting under normal service conditions.
3. Clean, distinctive appearance that lasts and lasts.
4. Approved by Underwriters' Laboratories, Inc.

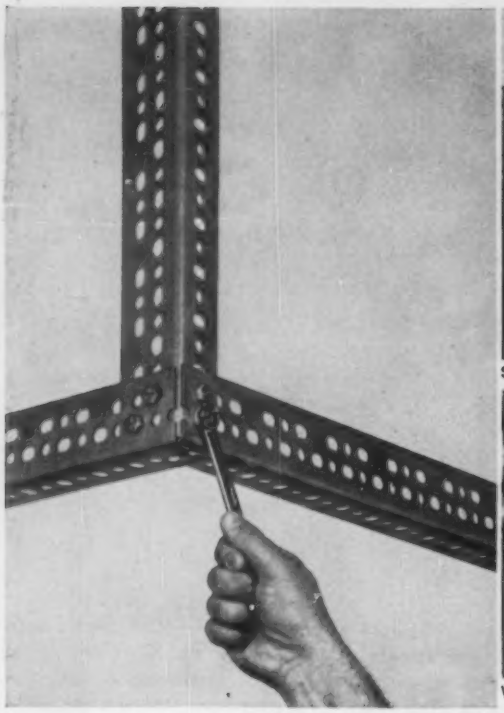
Take advantage—now—of the many new benefits offered by Alcoa Aluminum Electrical Rigid Conduit. Immediate delivery of conduit, couplings and elbows in sizes 1 in. to 6 in. from strategically located distributor stocks. Aluminum Company of America, 2140-E Alcoa Building, Pittsburgh 19, Pennsylvania.

Your Guide to the Best in Aluminum Value

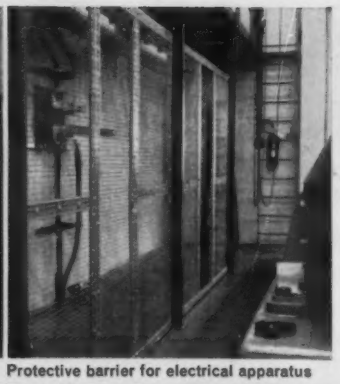
ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

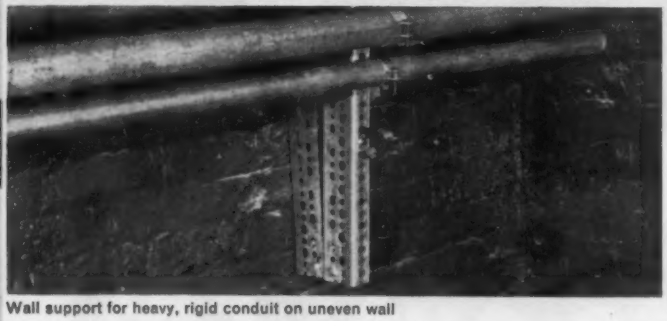
For Exciting Drama Watch "Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," Every Tuesday, ABC-TV



Support for switch gear



Protective barrier for electrical apparatus



Wall support for heavy, rigid conduit on uneven wall

SAVE ON EVERY KIND OF INSTALLATION

WITH new AIM BRAND Slotted Angle

Cut job costs on all your electrical installations with new AIM Brand Slotted Angle—the only framing material that gives you Lock-Joints, Friction-Joints and ⅜" structural bolts.

It's easy and economical to use this new framing material as supports, framing, mountings or wherever you need strong, yet convenient, structural assembly. The exclusive new slot-and-hole bolting pattern provides ready-made openings for anchors and attachments. All standard electrical fittings can be used. No reaming is necessary.

Friction-Joints are quickly formed by bolting through the slots. The ⅜" structural bolts fit round holes precisely to form Lock-Joints when maximum rigidity is needed. Each bolt has a safe load capacity of 2000 pounds.

Fabricate right on the job site with AIM Brand Slotted Angle. No drilling or welding is required. Save on installation time . . . save on initial material cost . . . save on handling and storing.

Of cold-rolled galvanized steel, this versatile framing material is available in two sizes: Standard 225-80 (2¼"x1½"x.080") and Heavy-duty 300-104 (3" x 1½" x .104"). Packaged in 10 or 12-foot lengths, ten pieces to a package. Nuts and bolts included.

AIM Brand Slotted Angle is a product of Acme Steel Company, U. S. pioneers in slotted angle framing material. Stocked locally by leading distributors or write: Dept. EBD-59, Fabricated Materials Division, Acme Steel Company, 135th and Perry Avenue, Chicago 27, Illinois.

ACME STEEL **AIM Brand Slotted Angle** AIM

WORLD'S MOST WIDELY USED
ELECTRICAL TEST INSTRUMENTS

AMPROBE®

THE ONLY LINE THAT COVERS ALL YOUR TESTING NEEDS

The original pocket size
snap-around volt-ammeter-ohmmeter

AMPROBE RS-3

5 current ranges. 3 voltage ranges. Ohmmeter specially designed for the maintenance field. Rotary scale for faster reading and greater accuracy. Pointer-Lock "freezes" pointer at reading. Advanced printed circuitry laughs at rough handling. Advanced movement design—new internal core magnet with self shielding characteristics. By itself, the Amprobe RS-3 handles 90% of your test needs. With the Amprobe Deca-Tran and Amprobe Energizer it covers EVERY testing situation.

Only $52.50

AMPROBE RS-1

The economy snap-around volt ammeter with many features of the great RS-3 including rotary scale, pointer lock, printed circuit, and advanced movement design. 4 current ranges. 2 voltage ranges.

Only $39.85

AMPROBE JR.

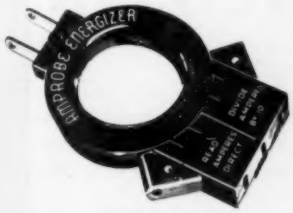
The advanced voltage tester that gives you current, too. Available in seven models, ranging from 10 amps to 100 amps in either 125/250 or 150/600 volts. Choose the model that fits your job.

Only $19.85

AMPROBE DECA-TRAN

Makes your Amprobe the world's most flexible and versatile electrical test instrument. Extends amperage reading 10 times. Gets readings as high as 1200 amps.

Only $24.75



AMPROBE ENERGIZER

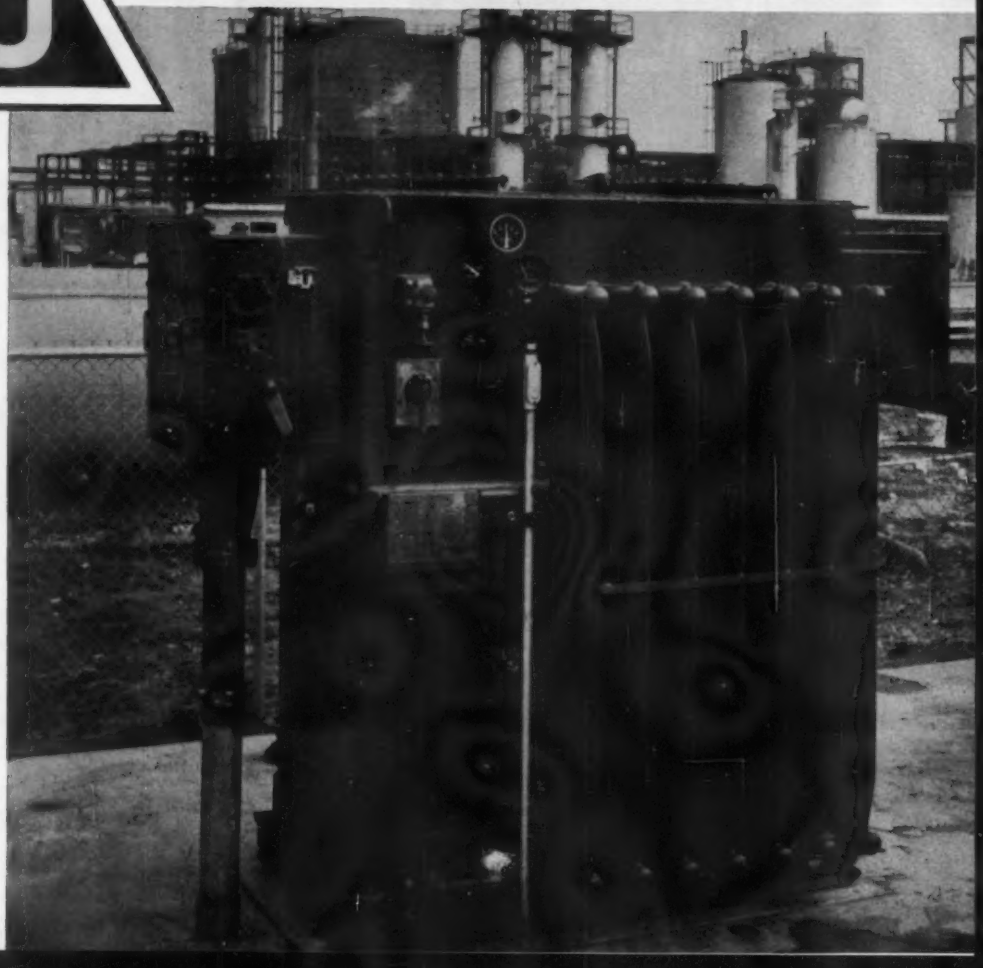
Multiplies the sensitivity of any Amprobe ten times—for precise readings on small appliances and fractional horsepower motors.

Only $3.75

PYRAMID INSTRUMENT CORPORATION, LYNBROOK, N. Y. WORLD'S LARGEST MANUFACTURER OF SNAP-AROUND VOLT-AMMETERS.

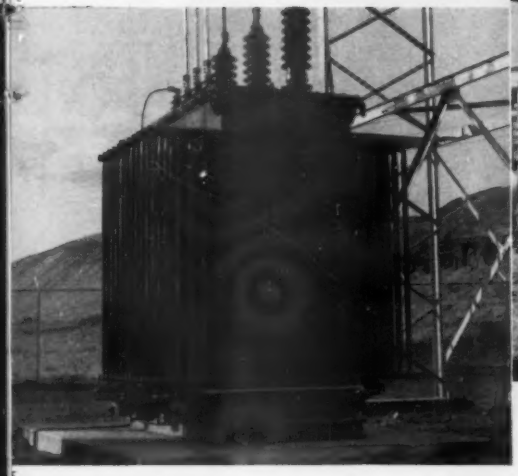
from

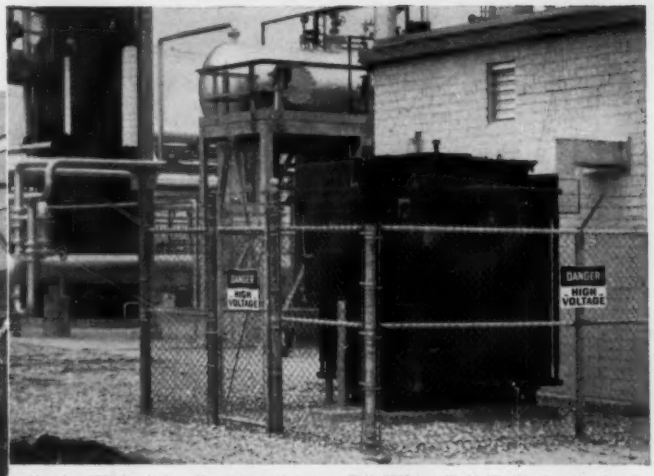
This 2500-kva Uptegraff power transformer, being installed at the Taunton Municipal Lighting plant in Massachusetts, is one of several units used in conjunction with a new 16,500-kw turbine unit.



One of several Uptegraff transformers furnishing power for the Benzene Toluene plant addition to the Richfield refinery at Wilmington, California. Long, trouble-free performance is vitally important in round-the-clock refinery operations.

MASSACHUSETTS to CALIFORNIA





Here is a 1500-kva Uptegraff power transformer located in Cleveland, Washington. It is one of several Uptegraff transformers serving the Klickitat County public utility at Goldendale.

This 1000-kva liquid-filled load center transformer is one of several Uptegraff transformers helping supply the power requirements for a new Celanese Plastics Division plant in Houston, Texas.

Uptegraff transformers serve industry's power needs!

The *extra* quality of today's Uptegraff transformers is due to a forward-looking program in research and development. This involves new and better raw materials, fabricating systems and assembly methods. It has resulted in important transformer advances . . . lasting oil preservation . . . completely leak-proof tanks and fittings . . . use of grain-oriented steel core for lighter weights, smaller sizes, lower core loss and exciting current . . . flow-painted exteriors assure three-mill paint coat and complete coverage . . . etc.

New designs provide capacity beyond normal rating

These improvements *plus* strict quality control in manufacturing and advanced testing methods assure the *extra* transformer capacity *beyond nameplate rating* to successfully withstand momentary overvoltages, high temperatures and other abusive conditions.

Meet the people of the Uptegraff Company

This picture-story booklet will give you an intimate view of the Uptegraff Company, and the people who design and build Uptegraff transformers. *Send for your copy TODAY.*

R. E. UPTEGRAFF MANUFACTURING CO.
SCOTTDALE, PENNSYLVANIA

There are two main considerations in lighting a drive-in restaurant. 1) Providing enough light for safe movement and parking of a large volume of traffic; 2) Providing a well-lighted area that readily identifies the drive-in and attracts passing motorists. The above drive-in accomplished this by mounting 3 floodlights and 5 clusterlites on each of 6 poles. Mounting height 33 feet, pole spacing 24 feet.

Revere matched outdoor lighting equipment means fast, trouble-free installation

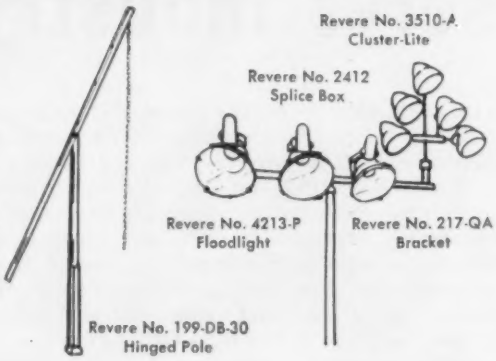
All components for the outdoor lighting installation shown above were made by Revere. All components—hinged poles, brackets, floodlights, cluster-lites and accessories—are made for each other.

By ordering your outdoor lighting from one reliable source, you can be sure that the equipment will fit together right when it gets to the job. This means fast, easy installation and less headaches for you.

You can also be sure that the components are structurally matched for strength and balance, and that they are matched in design for peak lighting efficiency and best appearance. All equipment from *one* source also means *one* delivery schedule from *one* manufacturer—all components reach the job at the same time.

Revere offers you the widest line of outdoor lighting equipment in the industry. No matter what the application, Revere has the equipment to do the job. Write for your copy of the Revere Catalog.

Revere components used in lighting drive-in restaurant



Revere ELECTRIC MFG. CO.

OUTDOOR LIGHTING

Revere Electric Mfg. Co. • 7420 Lehigh Avenue • Chicago 48, Illinois (In suburban Niles)
Long Distance Phone: NIles 7-6060 • Chicago Phone: SPring 4-1200 • Telegrams: WUX Niles
In Canada: Curtis Lighting, Ltd., Leaside, Toronto, Ontario

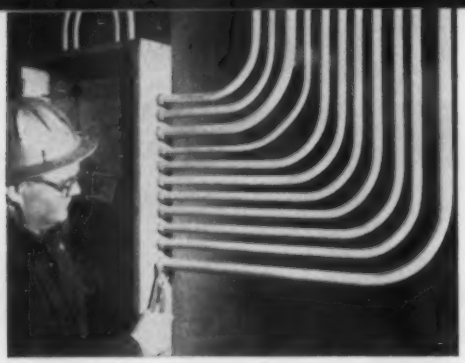
THIS SEAL STANDS FOR...

- Quality Products
- Easier Installation
- Prompt Delivery
- The Right Price
- Constant Research
- Continuous Growth

Ettco

ETTCO WIRE & CABLE
CORPORATION

General Offices: 46-50 Metropolitan Avenue, Brooklyn 37, New York
Plant: 75 Onderdonk Avenue, Brooklyn 37, New York
Cable Address: "ETTCO"



At Detroit's Pavilion Apartments, Youngstown "Buckeye" Conduit is being attached to electrical control box.

Accent on Excellence

Youngstown "Buckeye" steel conduit

Detroit's new, modern-as-tomorrow Pavilion Apartments, designed by architect Mies Van Der Rohe, has lifetime electrical wiring protection —thanks to Youngstown "Buckeye" Rigid Steel Conduit.

Electrical systems that function improperly are a bad investment. To be sure your installations are both safe and efficient, always specify "Buckeye" Conduit. It's been the consistent choice of leading architects, contractors and building owners over the years.

When you specify "Buckeye" Conduit, the high standards of Youngstown *quality*, the personal touch in Youngstown *service* will help you create electrical wiring systems with an "accent on excellence".

PAVILION APARTMENTS, DETROIT, MICHIGAN

OWNER:
Herbert S. Greenwald, Metropolitan Corporation of America, Chicago, Illinois

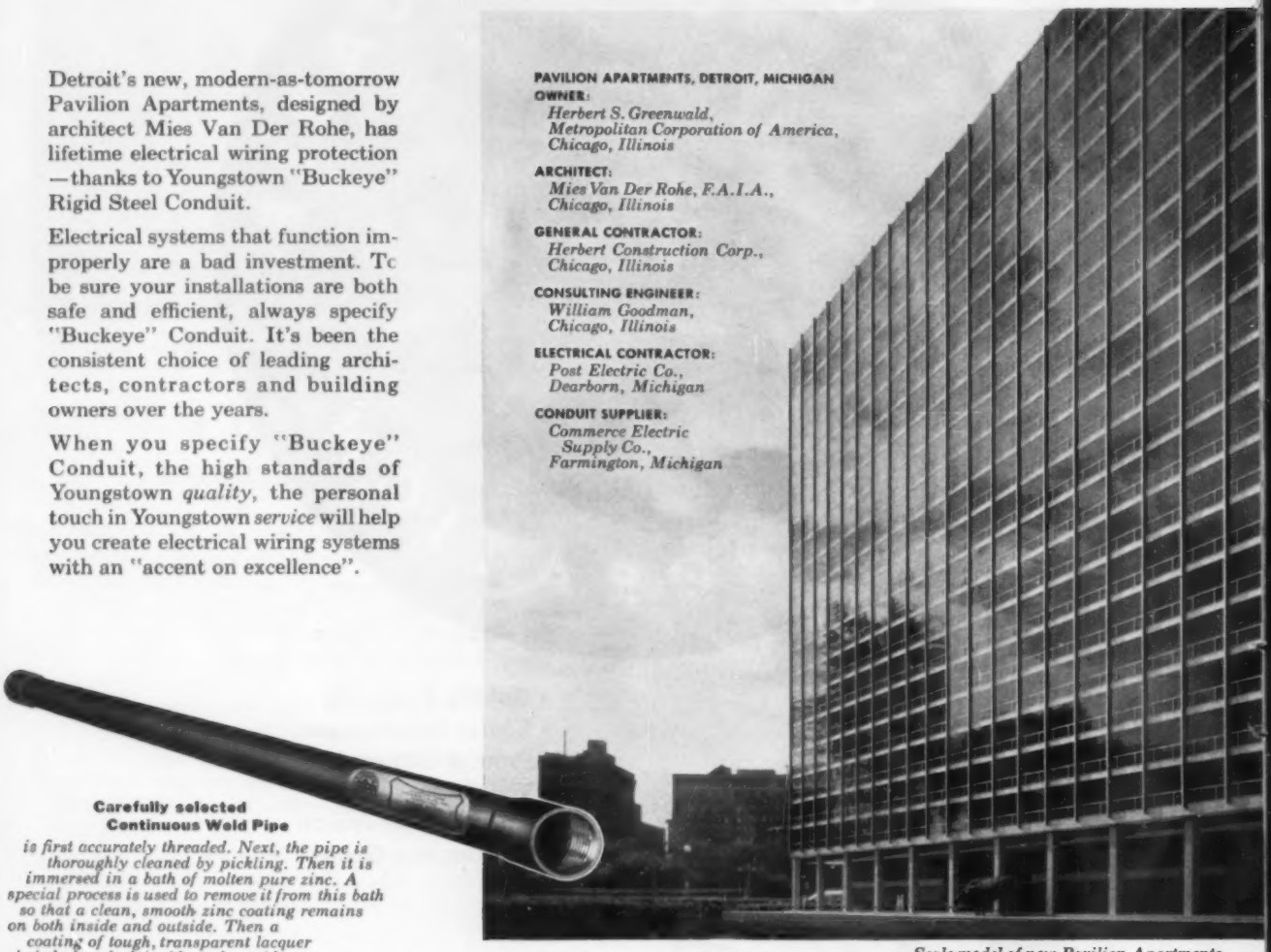
ARCHITECT:
Mies Van Der Rohe, F.A.I.A., Chicago, Illinois

GENERAL CONTRACTOR:
Herbert Construction Corp., Chicago, Illinois

CONSULTING ENGINEER:
William Goodman, Chicago, Illinois

ELECTRICAL CONTRACTOR:
Post Electric Co., Dearborn, Michigan

CONDUIT SUPPLIER:
Commerce Electric Supply Co., Farmington, Michigan



Scale model of new Pavilion Apartments.

Carefully selected Continuous Weld Pipe

is first accurately threaded. Next, the pipe is thoroughly cleaned by pickling. Then it is immersed in a bath of molten pure zinc. A special process is used to remove it from this bath so that a clean, smooth zinc coating remains on both inside and outside. Then a coating of tough, transparent lacquer is baked on both inside and outside surfaces, providing a smooth raceway through which wires may be easily fished. This is Youngstown's long-lasting, trouble-free, easy bending hot galvanized Buckeye Conduit.

QUALITY YOUNGSTOWN SERVICE

Youngstown
Youngstown, Ohio

THE YOUNGSTOWN SHEET AND TUBE COMPANY

Carbon, Alloy and Yoloy Steel

the beauty . . .
the design . . .
the performance . . .
you've hoped for in one switch–

Push It, Press It,
Roll It, Rock It

No matter how you choose to operate the new ROCKER-GLO, the merest brush of a finger produces instant action . . . and *ROCKER-GLO glows in the dark!* The switch that *looks* right, *feels* right and *is* right for every type of wiring job.

the new P&S® **ROCKER-GLO SWITCH**

After intensive testing, Pass & Seymour proudly presents ROCKER-GLO . . . the one switch that answers all your needs.

A switch that is trouble-free and packed with eye-appeal.

ROCKER-GLO does the job of all types of switches. It combines toggle action and press action with luminous and quiet features that answer all individual customer needs.

You can tell when it's on or off.

Rocker-Glo — *The Specification Grade Switch*

AVAILABLE in Despard interchangeable type, Despard type mounted on strap and narrow rocker for tumbler switch plates. A specification grade switch, 15 and 20 amps. 120/277 volts A.C.

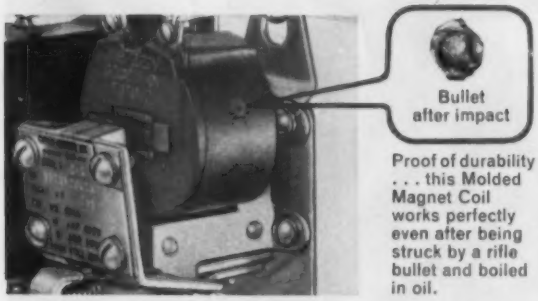
Send for brochure on Rocker-Glo Dept. ECM-559

P&S

PASS & SEYMOUR, INC.
SYRACUSE 9, NEW YORK
60 E. 42nd St., New York 17, N. Y. 1440 N. Pulaski Rd., Chicago 51, Ill.
In Canada; Renfrew Electric Limited, Renfrew, Ontario

New Reduced Voltage famous Cutler-Hammer

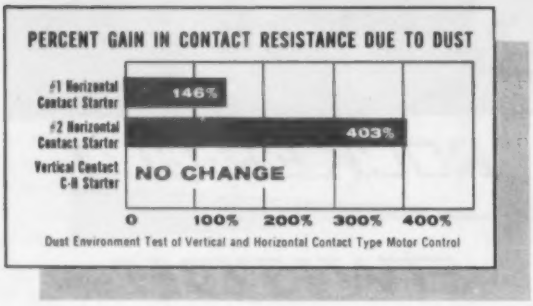
MOLDED MAGNET COILS



Proof of durability . . . this Molded Magnet Coil works perfectly even after being struck by a rifle bullet and boiled in oil.

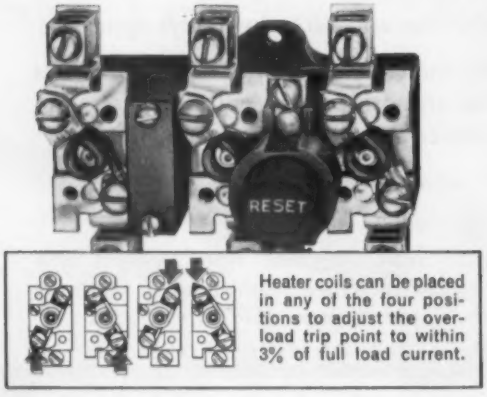
The strength and durability of the Cutler-Hammer Molded Magnet Coil is but one example of how Cutler-Hammer Reduced Voltage Control is built better to last longer. Rifle bullets couldn't pierce or shatter this coil. What chance is there of it being damaged when an electrician's screwdriver slips or when the coil is dropped? Boiling oil has no effect on this coil. What chance is there of it ever being penetrated by moisture or distorted by high ambient temperatures?

VERTICAL DUST-SAFE CONTACTS



To function properly motor control contacts *must* stay clean. And because dust can't collect on a vertical surface, only vertical contacts are truly *dust-safe*. Recent dust-chamber tests of vertical and horizontal contact type motor starters confirm this fact. After four hours of "dusting", the contact resistance of Cutler-Hammer vertical contacts remained constant. But the contact resistance of horizontal contacts skyrocketed, and as contact resistance increases so does heating, pitting, and wear resulting in rapid contact failure.

ADJUSTABLE 3-COIL OVERLOAD RELAYS

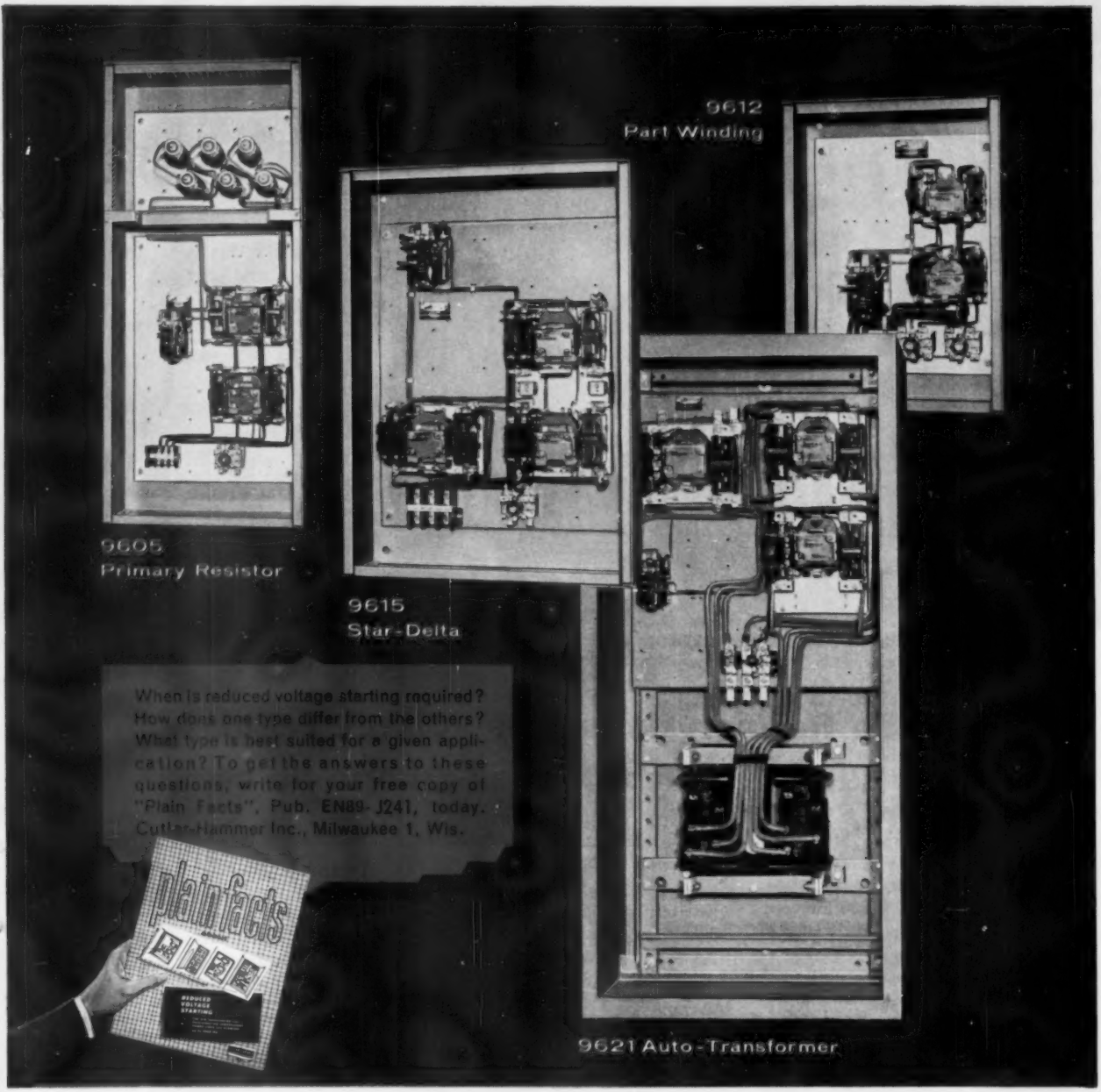


Heater coils can be placed in any of the four positions to adjust the overload trip point to within 3% of full load current.

Only 3-coil overload relays can provide dependable overload protection for three-phase motors under all operating conditions. Why gamble with costly motor burnouts by using motor control that protects only two of the three motor windings? 3-coil overload relays can be provided in all standard Cutler-Hammer Reduced Voltage Control, no oversize enclosures. Further, Cutler-Hammer Overload Relays are adjustable to within 3% of full load motor current, not 10% or 12% as others. Cutler-Hammer Overload Relays allow the motor to work up to full capacity, provide positive protection without nuisance tripping.

Molded magnet coils, vertical *dust-safe* contacts, and adjustable 3-coil overload relays are *plus* features that add up to *bonus* performance whenever you install Cutler-Hammer Reduced Voltage Control. Why settle for less when Cutler-Hammer Reduced Voltage Control costs no more.

Control with all the Three-Star Features

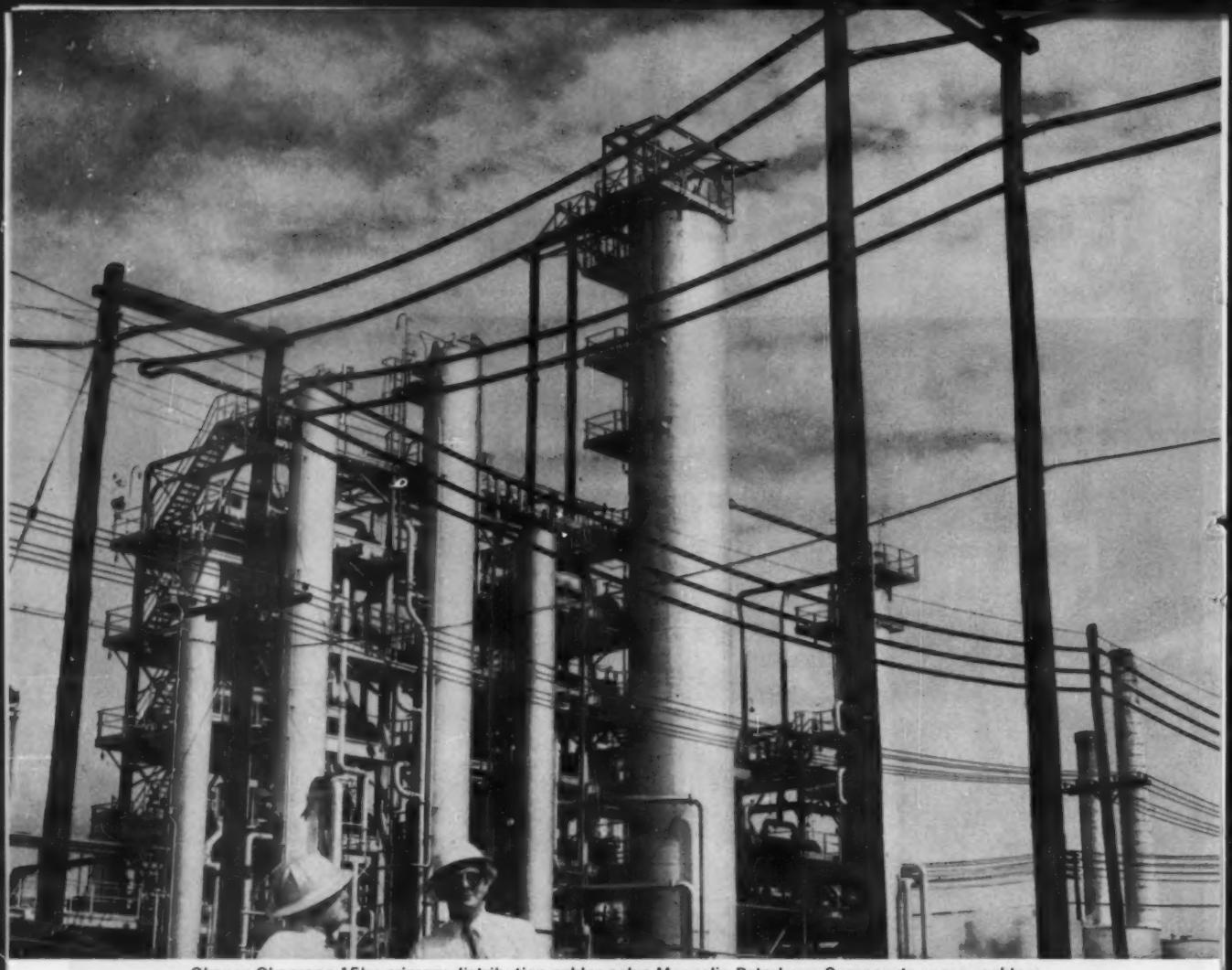

9612
Part Winding
9605
Primary Resistor
9615
Star-Delta
When is reduced voltage starting required? How does one type differ from the others? What type is best suited for a given application? To get the answers to these questions, write for your free copy of "Plain Facts", Pub. EN89-J241, today. Cutler-Hammer Inc., Milwaukee 1, Wis.
plainfacts
9621 Auto-Transformer

CUTLER-HAMMER CONTROL

CUTLER·HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* **Airborne Instruments Laboratory.** • *Subsidiary:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.



Okonex-Okoprene 15kv primary distribution cables solve Magnolia Petroleum Company's space problem and climate problem (wet and salty atmosphere) and provide greater safety in its Beaumont refinery.

Magnolia Refinery improves voltage regulation, beats humidity with Okonex-Okoprene cables

The giant 1,500-acre Magnolia Petroleum Company refinery, located on the broad Gulf Coast Plain, generates and uses 900,000 kilowatt hours a day, more than its neighboring city of Beaumont, Texas. A cable breakdown here could cause costly damage to equipment and the material in process (more than 400 oil products are manufactured). The entire cable system must serve Magnolia's round-the-clock operation without interruption in the face of the high moisture-saline content of the air, plus the chemicals and intense heat used at many of the processing units.

For the 15kv primary aerial loop distribution system, Magnolia's engineers selected shielded Okonex-Okoprene cables. These butyl-base insulated, neoprene-sheathed constructions saved space, eliminated safety problems and provided improved voltage regulation far superior to previous open wire constructions and other insulated cable constructions studied. In addition, their excellent moisture, heat and corrosion resistance were important assurances of maximum service life.

Okonex-Okoprene, in 3,000 to 15,000 volt constructions, was also used for trunk feeders to and from substations, tie lines and motor leads installed both aerially and underground.

To help you specify the optimum cable for your important power and control cable needs, contact your Okonite representative or write for the free Bulletin EC-1117, "How to choose insulated cable," to The Okonite Company, Passaic, New Jersey.

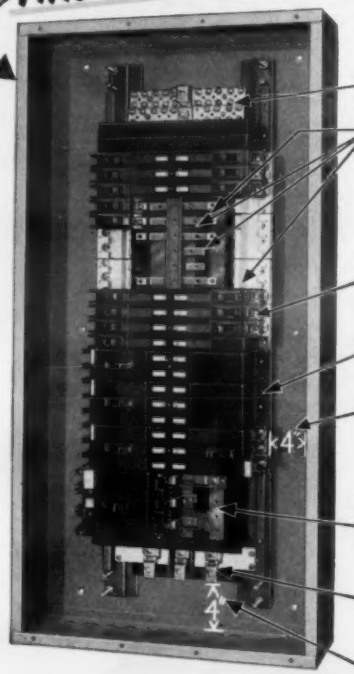
where there's electrical power . . . there's **OKONITE CABLE**

6339

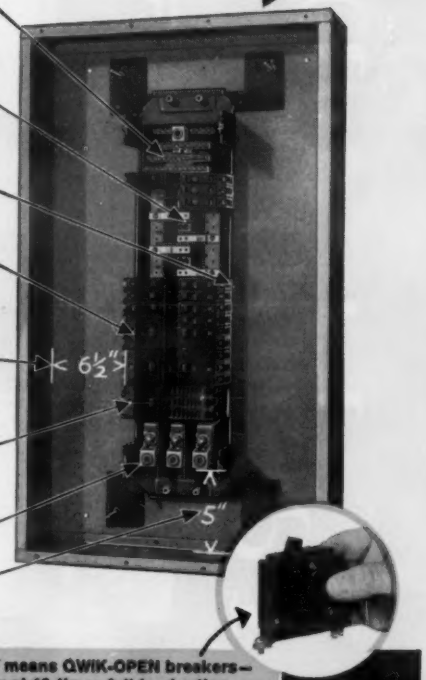
YOU ARE LOOKING AT THE GREATEST IMPROVEMENT IN PANELBOARDS IN MORE THAN 20 YEARS!

This is what you've been using

This is what Square D's New NQOB Gives You*



Binder-head Screw Neutral Taps	Box-type Neutral Lugs
Large Number of Parts Required for Additions and Replacements	Simplified Breaker Connection— One Screw All Joints Plated Bussing Like Wiring Diagram You Can See What Phase You're Connected To
Screw Terminals on Branch Circuit Breakers	Box Lugs on All Circuit Breakers
Unable to Mount One and Two Pole Breakers Opposite Three Poles	One and Two Pole Breaker May Mount Opposite Three Poles
Cramped Side Gutters	20"-wide Box Provides Roomy Side Gutters and Plenty of Room for Conduit in End Wall
Special Installation Required for 100 Amp Frame Breakers	100 Amp Frame Breaker May Replace Two 50 Amp Frame Breakers
Lugs for Copper Conductors Only	Lugs for Either Copper or Aluminum UL Approved
Minimum End Gutters	Full 5" End Gutters



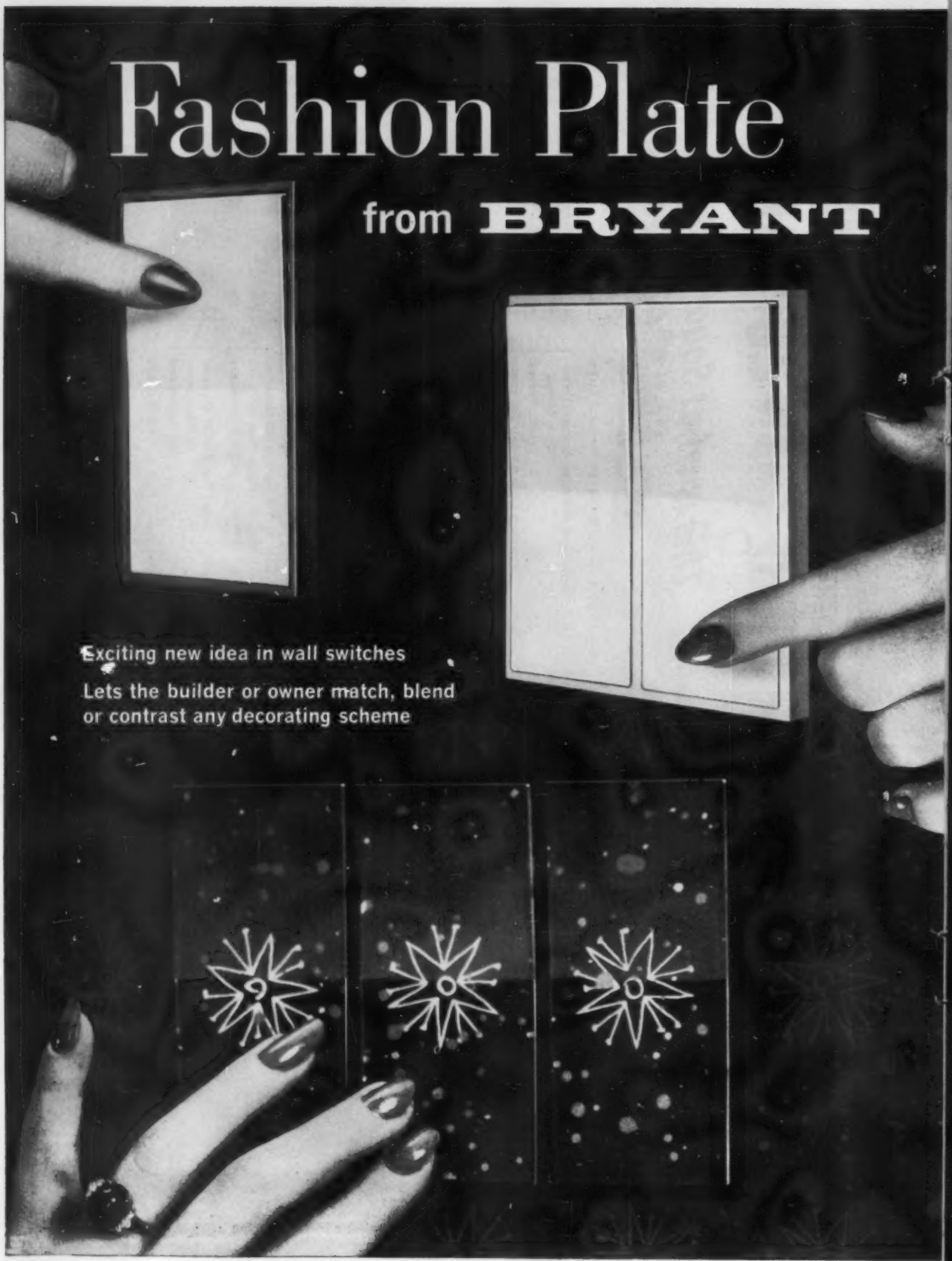
Write for the complete story Square D Company, 6060 Rivard Street, Detroit 11, Michigan

SQUARE D COMPANY

* The QO in NQOB means QWIK-OPEN breakers—they trip instantly at 10 times full load rating. The B in NQOB means BOLTED CONNECTIONS. If you prefer plug-in construction, specify NQO

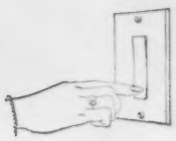
Fashion Plate

from BRYANT



Exciting new idea in wall switches

Lets the builder or owner match, blend or contrast any decorating scheme



TAP-EEZ . . . new tap-action, flush-mounted switch for buildings, institutions and stores. Rugged enough for all a-c applications, yet much more attractive than ordinary switches.

WINS NEW CUSTOMERS . . . CAPTURES MORE BUILDER DOLLARS

Fashion Plate opens the door to more business in new construction . . . for homes, buildings, institutions . . . brings you a bigger share of the total building dollar

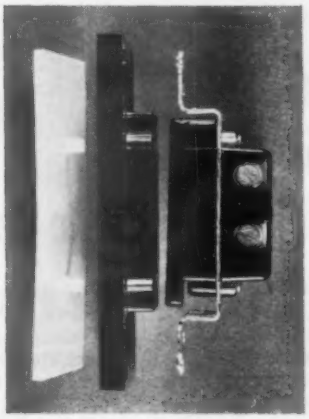
There's real excitement about Fashion Plate* among builders and architects. They are taking a second look at wall switches. That means you'll see Fashion Plate in more and more specifications . . . in more and more new homes and buildings. And you are the one who profits.

Right now, builders all over the nation are being supplied with a brand-new merchandising package for Fashion Plate. And they are being sent to you to supply their wiring needs.

Don't wait. Stock up now before the big building rush this summer. Next job you wire, suggest Fashion Plate. It's an exciting new product that wins customers and builds profits.

*Trade-Mark

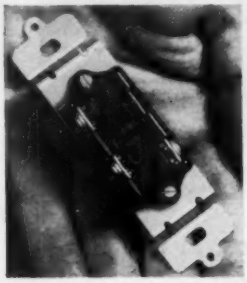
ASK YOUR BRYANT DISTRIBUTOR for a sample of Fashion Plate. Take it apart and see the built-in quality . . . the trade-mark of Bryant superior wiring devices.



Smooth, quiet action. Low installation cost. Just press on back plate and actuator.

UNLIMITED APPLICATIONS—AVAILABLE IN SINGLE, DOUBLE AND THREE GANG COMBINATIONS—WITH CLEAR OR IVORY ACTUATORS, BLACK OR WHITE BACK PLATES

Silver alloy contacts insure long life. Positive controlled contact action. Listed by Underwriters' Laboratories, Inc.



Compact design. Fits standard switch boxes. Requires no special wiring.

Time-saving, clamp-type, back wiring terminals make installation quick and easy.

Fashion Plate

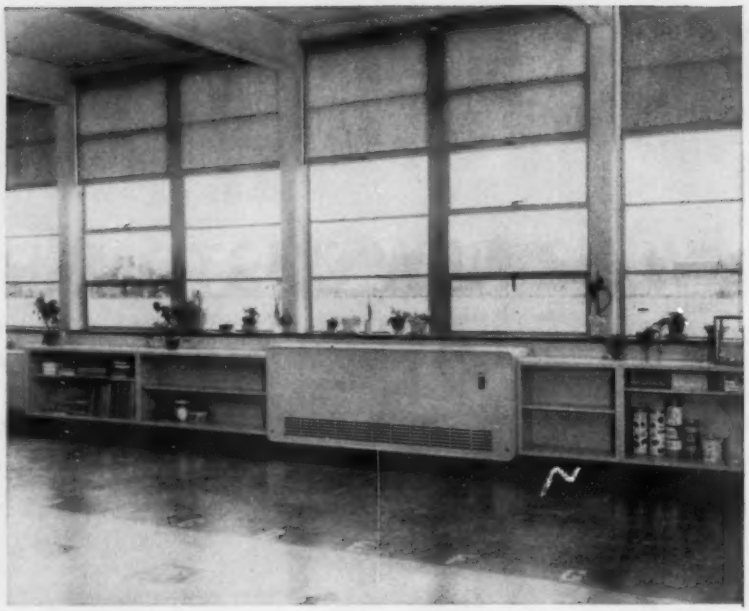
the exciting things come from

BRYANT

THE BRYANT ELECTRIC COMPANY, BRIDGEPORT 2, CONNECTICUT

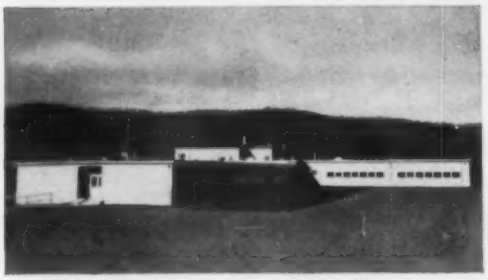
J-99024

Northern Pike Elementary School
Monroeville, Pennsylvania



Woodbine Elementary School
Cicero, Illinois

Angola Elementary School—Lake Shore, New York



Jenkins Elementary School
West Portsmouth, Ohio

Chromalox electric . . . the heat of the future is here:

Brookside School
Kingsport, Tennessee

Richland Township School
Anderson, Indiana

Windsor Elementary School
Longstown, Pennsylvania

Bell School
Niles, Michigan

St. Ambrose School
Seymour, Indiana

Braceville Elementary School
Newton Falls, Ohio

Beaver Dam School
Beaver Dam, Ohio

Lexington Elementary School
Addition
Lexington, Ohio

For year-round comfort . . . safety . . . economy . . . CHROMALOX . . . First in electric heat

More and more plans for modern schools make no provision for a boiler room. Instead, the space and dollar savings realized from low original cost Chromalox electric heating equipment is used to plan additional rooms and other facilities. With electric heat, total *operating* costs can be lower, too. We can give you case history proof.

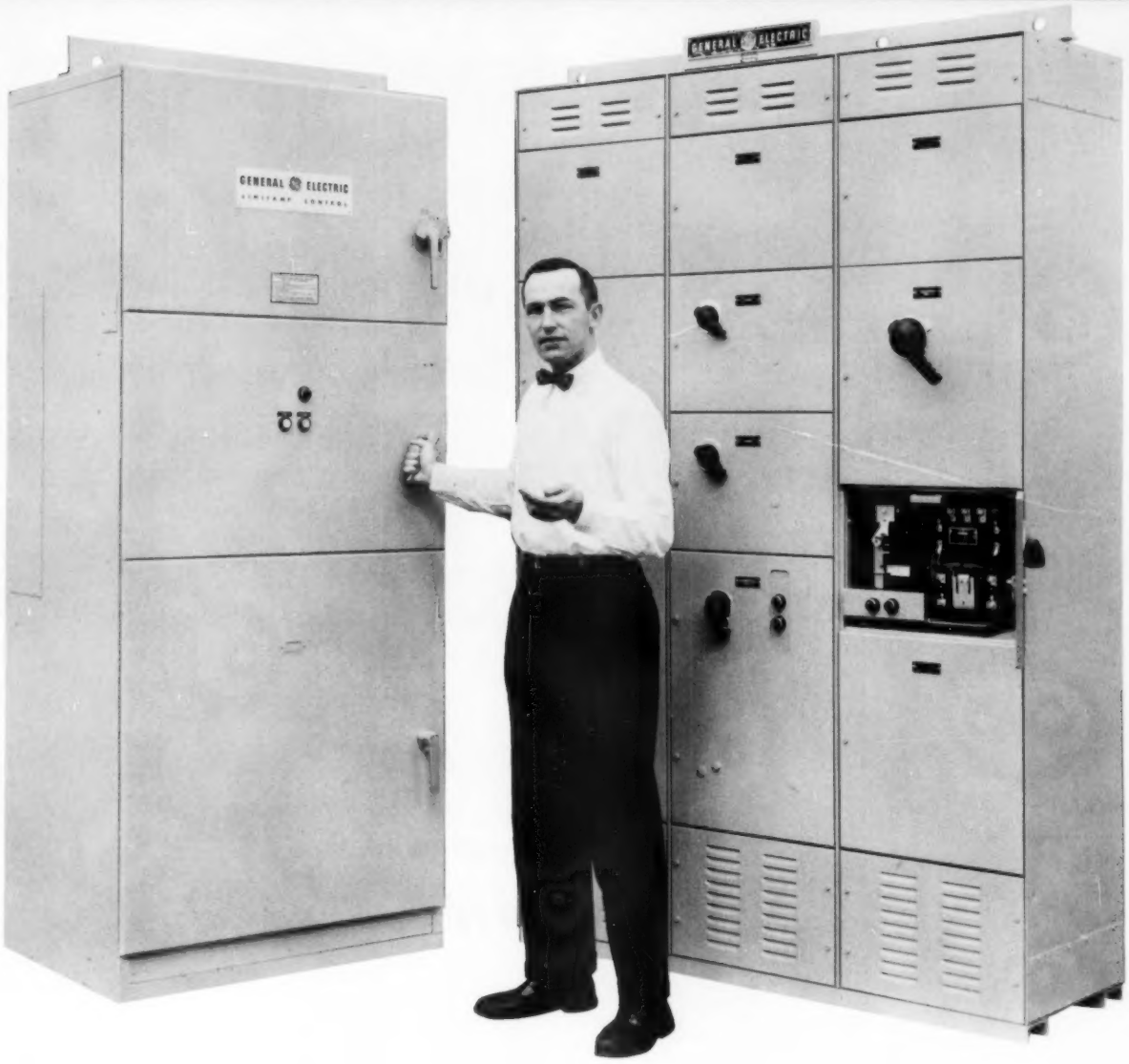
And what price tag do you put on safety . . . or on true year-round comfort? With Chromalox electric heat, you get individual room control, elimination of down drafts, fresh air ventilation and natural cooling.

The Chromalox electric way is also the easy, economical way to replace worn out heating systems in present schools, and plan heat for school expansions.

Don't plan modern facilities around an old fashioned boiler room. Send today for Bulletin 990B . . . "The Dollars and *Sense* Story of Heating Schools Electrically."

4990

CHROMALOX
Electric Heat
INDUSTRIAL • COMMERCIAL • RESIDENTIAL
EDWIN L. WIEGAND COMPANY
7637 Thomas Boulevard • Pittsburgh 8, Pa.

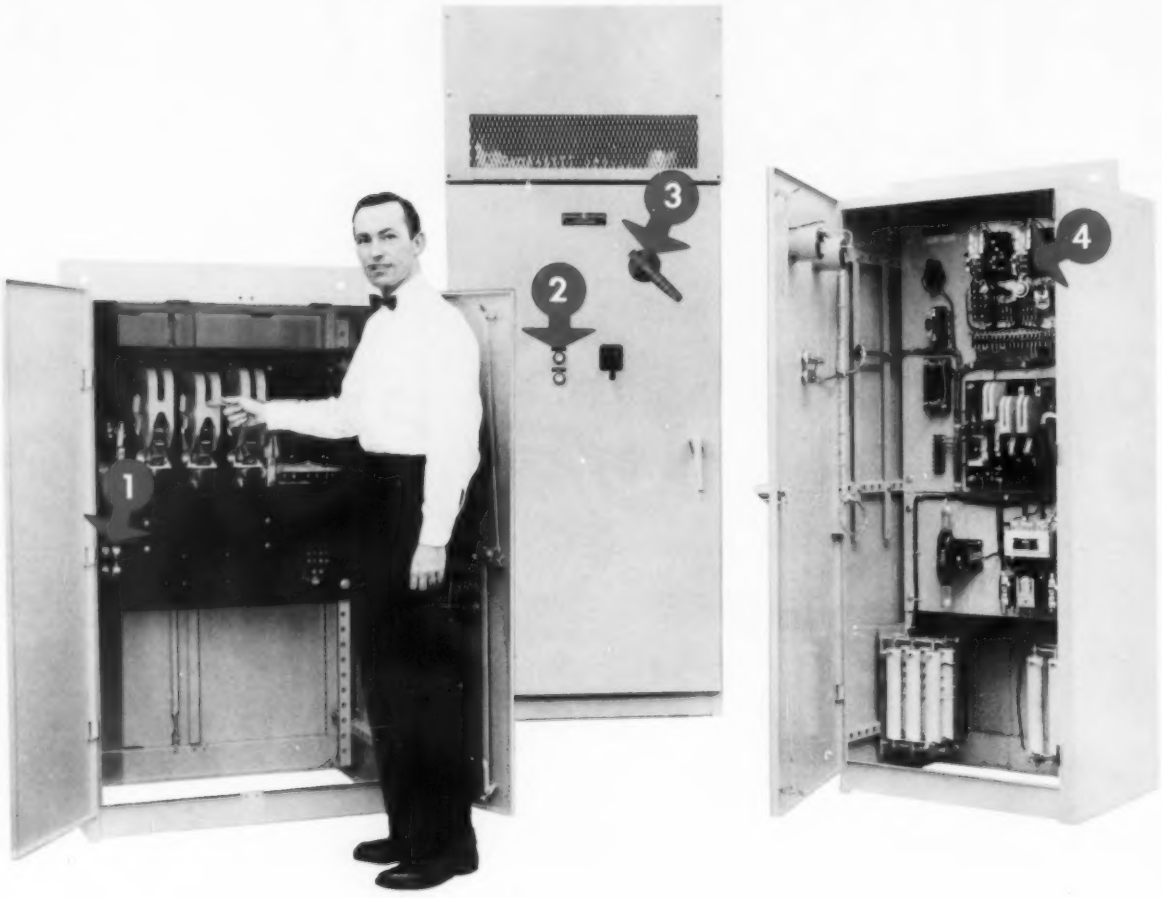


IN 96 SECONDS, *see how every member of General Electric's motor-control family offers feature after feature for . . .*

Greater protection of your equipment and personnel

GENERAL ELECTRIC

Get greater protection of equipment



LOW-VOLTAGE INDIVIDUAL STARTERS

For squirrel-cage, wound-rotor and synchronous motors

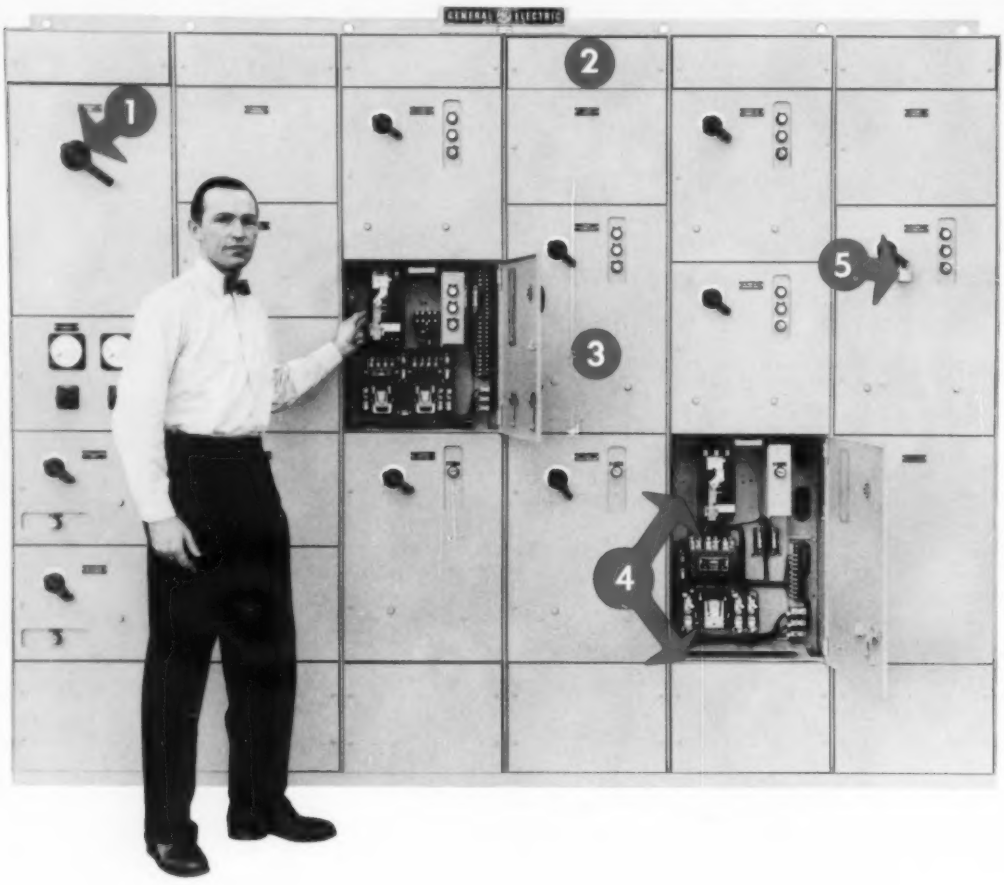
1. **OVERLOAD RELAYS** on General Electric's individual motor controls constantly protect the motor against damage from overloads.
2. **UNDERVOLTAGE PROTECTION** is provided by momentary-contact pushbuttons on applications where automatic restarting after power loss is not desired. Undervoltage release by maintained-contact pushbuttons is available for applications where automatic restarting is desired.
3. **SHORT-CIRCUIT PROTECTION** against faults up to 100,000 amperes can be provided. Fuses, circuit breakers, and fuse-breaker combinations are available.
4. **SYNCHRONOUS MOTOR PROTECTIVE SYSTEM** allows maximum utilization of the motor, yet gives full protection against out-of-step operation with field applied. Squirrel-cage winding has graduated protection that prevents overheating during starting, yet does not cause unnecessary tripping.

Write for bulletin GEA-6584 to Sect. 783-8, General Electric Co., Schenectady, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

and personnel with these features



LOW-VOLTAGE MOTOR CONTROL CENTERS

For flexible grouped control of motors up to 400 hp

1. **INTERLOCKED DOOR HANDLES** automatically operate the breaker or fused switches and de-energize the starter units when handles are turned to "OPEN" position, thus the doors cannot be opened when the starter is energized.

2. **SHORT-CIRCUIT PROTECTION** up to 100,000 amperes is available with fuses or reactor in incoming line.

3. **STURDY ENCLOSURE** is constructed of bolted sheet-metal with an "I-beam" frame. This protects starters and internal wiring from mechanical damage. Full-length floor sill adds to strength of enclosure.

4. **ISOLATED STARTER COMPARTMENTS** are separated from the main power bus and other starter compartments by horizontal and vertical metal barriers.

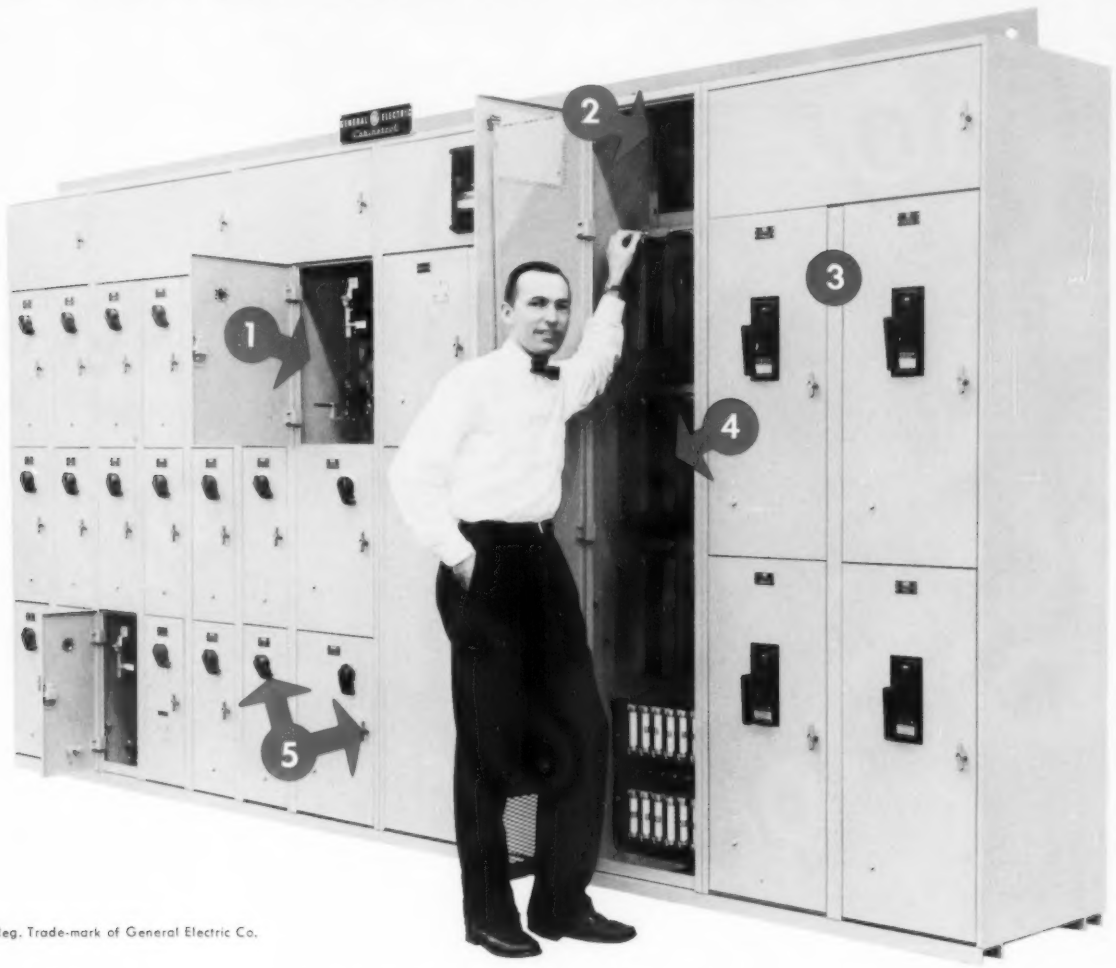
5. **LOCKING DEVICE** on compartment handle can be used to lock starters in position to prevent unauthorized operation and to prevent starter from being energized during maintenance.

Write for bulletin GEA-4979 to Sect. 783-8, General Electric Co., Schenectady, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

es of General Electric motor control



*Reg. Trade-mark of General Electric Co.

LOW-VOLTAGE CABINETROL* POWER CENTERS

For custom-engineered grouped control of motors up to 900 hp

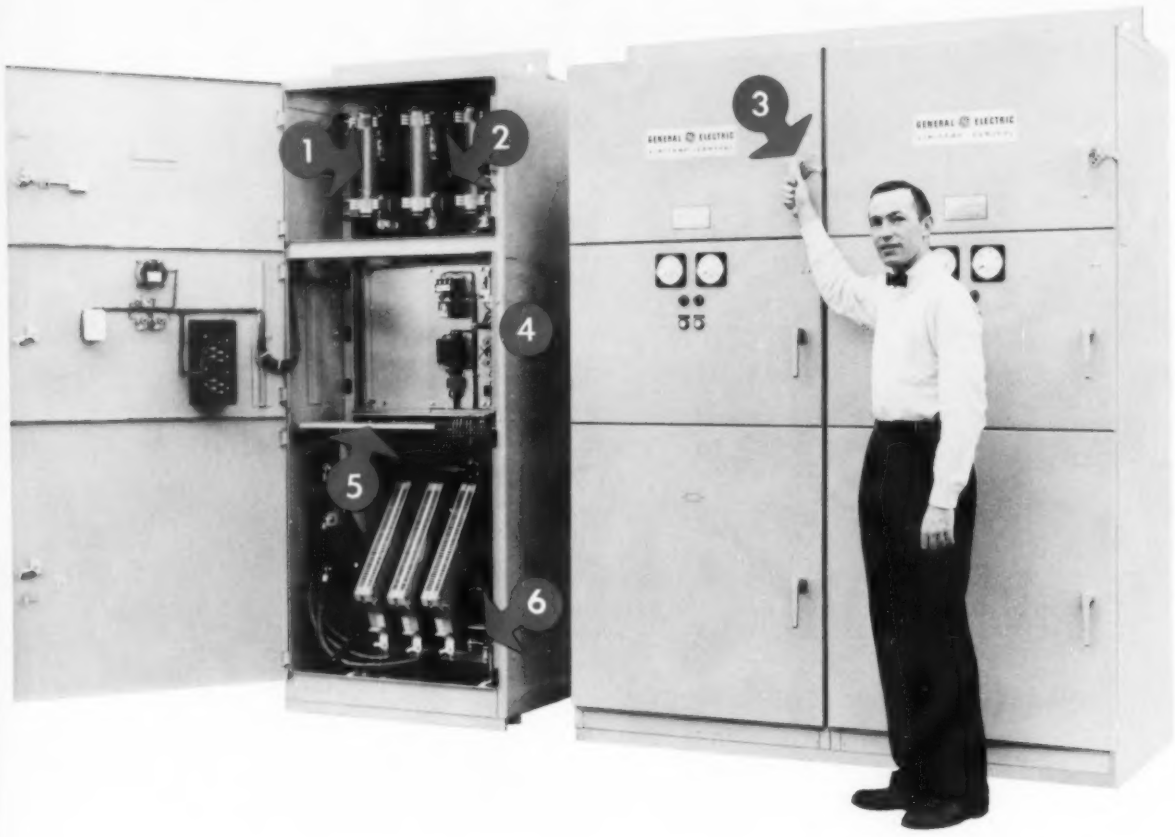
1. **METAL BARRIERS** between starter compartments protect personnel during inspection and maintenance. Starter compartments are isolated from each other and from the main bus.
2. **RUGGED ENCLOSURE** of these General Electric power centers is constructed of welded one-piece sheet steel to protect starters and internal wiring from mechanical damage.
3. **SHORT-CIRCUIT PROTECTION** up to 100,000 amperes is available for the power center in any one of three systems: fully rated, cascade, or backup.
4. **CAPACITOR BANKS** for power-factor correction can be provided to protect against excessive power losses.
5. **INTERLOCKED DOOR HANDLES** on the Cabinetrol power centers require that the starter unit is de-energized before door can be opened. Breaker handle can be locked in position and each compartment has a separate cylinder lock to prevent unauthorized entry.

Write for bulletin GEA-3856 to Sect. 783-8, General Electric Co., Schenectady, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

and personnel with these features



*Reg. Trade-mark of General Electric Co.

MEDIUM-VOLTAGE LIMITAMP* STARTERS

For individual or grouped control of motors up to 3000 hp

1. **HIGH-INTERRUPTING CAPACITY** fuses limit fault current within ¼-cycle. Limitamp starters have short-circuit capacities up to 150,000 KVA at 2300 volts, and 250,000 KVA at 4000 or 4600 volts, 60 cycles.
2. **VISUAL CHECK** of three-phase isolating switch shows personnel that unit is isolated from high-voltage power.
3. **ISOLATING SWITCH** is operated from outside the enclosure. High-voltage compartment doors cannot be opened until starter has been isolated from incoming power.
4. **MOTOR IS PROTECTED** against overload by ambient-compensated overload relays. All Limitamp control components are co-ordinated to withstand the stresses of short circuits.
5. **METAL BARRIERS** separate the high-voltage and the low-voltage compartments.
6. **INTERLOCK SYSTEM** on this General Electric control prevents operation of the isolating switch until the contactor has been completely de-energized.

Write for bulletin GEA-6331 to Sect. 783-8, General Electric Co., Schenectady, N. Y.

FOR MORE INFORMATION AND APPLICATION ASSISTANCE on any of G.E.'s motor controls, contact your G-E Apparatus Sales Office.

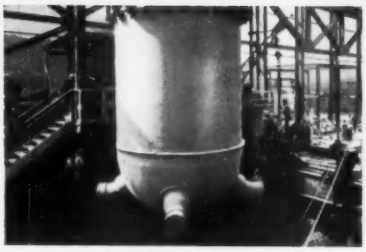
LIFT

GENERAL ELECTRIC

YOUR FUTURE IS GREAT IN A GROWING AMERICA

ELECTRONICS

Electronics is one of our fastest growing industries. By 1965 there will be thousands of new needs and new jobs.



NUCLEAR ENERGY

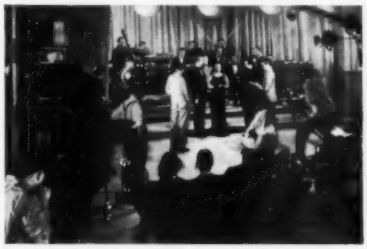
Nuclear energy is now supplying power for ships and electric plants. Future possibilities are virtually unlimited.

HEALTH

Ever-increasing opportunities in research, development and production. In the field of antibiotics 50% more workers will be required.

CHEMICALS

Today there are more than 800,000 workers in chemicals and related industries. By 1970, there will be *twice* as many!



COMMUNICATIONS

As our nation grows, the demands made upon communications grow proportionately. Thousands more needs, more jobs.

EDUCATION

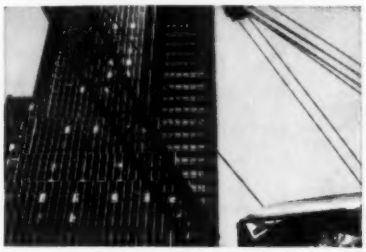
The giant school-building program now beginning will offer new jobs to many thousands of construction workers.

TRANSPORTATION

Our growing population demands constantly increasing mobility. Result: thousands of new opportunities, new jobs in the coming Jet Age.

FOODS

The trend is to labor-saving, ready-to-eat packaged foods. This new phase of an old industry will need thousands more workers.



CONSTRUCTION

3 million workers will benefit from new highway and construction programs—and even more workers will be needed soon.

7 BIG REASONS FOR CONFIDENCE IN AMERICA'S FUTURE

1. MORE PEOPLE—Four million babies yearly. U. S. population has *doubled* in last 50 years! And our prosperity curve has always followed our population curve.

2. MORE JOBS—Though employment in some areas has fallen off, there are *15 million* more jobs than in 1939—and there will be *22 million more* in 1975 than today.

3. MORE INCOME—Family income after taxes is at an all-time high of $5300—is expected to pass $7000 by 1975.

4. MORE PRODUCTION—U. S. production *doubles* every 20 years. We will require millions more people to make, sell and distribute our products.

5. MORE SAVINGS—Individual savings are at highest level ever—*$340 billion*—a record amount that is now available for spending.

6. MORE RESEARCH—*$10 billion* spent each year will pay off in more jobs, better living, whole new industries.

7. MORE NEEDS—In the next few years we will need more than *$500 billion* worth of schools, highways, homes, durable equipment. Meeting these needs will create new opportunities for everyone.

* * *

Add them up and you have the makings of another big upswing. Wise planners, builders and buyers will act *now* to get ready for it.

MARKETING

Marketing includes sales, consumer research, product and package design, advertising and public relations. All need new skills every year—and *many thousands* of new workers!

FREE! Send for this new illustrated booklet, "Your Great Future in a Growing America." Drop a postcard to: ADVERTISING COUNCIL, Box 10, Midtown Station, New York 18, N.Y.

GREAT FUTURE IN GROWING AMERICA

PUBLIC SERVICE ADVERTISING COUNCIL

"ONE LOOK ABOVE THE CEILING LINE WILL TELL YOU WHY SPEEDOMATIC IS TODAY'S FASTEST-INSTALLING TROFFER!"

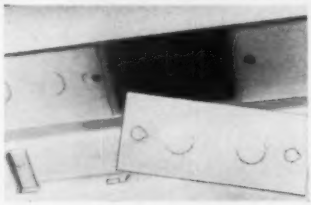
new Smithcraft SPEEDOMATIC TROFFERS

WITH THE EXCLUSIVE TELESCOPIC DOOR FRAME

It's no secret that the aptly-named new Smithcraft Speedomatic is today's fastest-installing troffer! From the telescopic door frame — that expands or contracts to assure perfect fit, even in irregular ceiling openings — to the large access door for fast, easy wiring, the new Speedomatic troffers are contractor-minded . . . designed to save you hours and dollars. Compare for yourself — and you'll agree that Smithcraft Speedomatic is truly the fastest-installing troffer on the market today.

THESE FEATURES HELP TO SPEED INSTALLATION TIME!

Exclusive telescopic door frame assures perfect-fitting jobs every time. Shallow design — only 4 15/16" deep.



Exclusive wiring access door saves installation time — large enough to reach through for feed wire.

Troffer installs in seconds, from below, by fast-travelling levelling screws. Only tool needed is a screwdriver.

Smithcraft Lighting CHELSEA 50, MASS.

FREE! The Smithcraft LIGHTESTER . . . enables your customers and prospects to "grade" their own lighting! A creative selling aid for you! For your sample LIGHTESTER, fill out and mail the coupon.

EC-5

Smithcraft Lighting Chelsea 50, Mass.

☐ Please send me a FREE sample LIGHTESTER and complete information on how I can use the LIGHTESTER to increase my sales.

☐ Please send me the complete Speedomatic catalog.

NAME .....

COMPANY .....

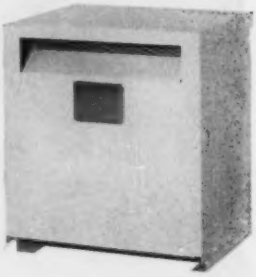
ADDRESS .....

CITY ..... STATE .....

"Hold it---I'll have this new Q

dry-type ready in a second!"

You'll save time and money every time you install a new General Electric QHT* dry-type transformer.



QHT dry-type transformers give you, in every rating, in every application, a balanced combination of small size, lightweight, superior installation features, high-temperature insulation and quiet operation. This combination means easier installation and practically eliminates the major sources of dry-type transformer complaints, noise and insulation failure.

Installation is easy with the new dry-types because the units are built with convenient knock-outs, large terminal compartments and wiring spaces which are easily accessible from the front. Lifting provisions are made for units weighing more than 65 pounds. These new transformers can be located at the load which eliminates the need for long, costly low-voltage feeders. No vaults, barriers, or ventilating fans are required.

A new insulation system—QHT dry-types have silicone impregnated insulation, highly moisture resistant, with an inherent ability to withstand high operating temperatures. Combined with materials such as aluminum conductors and cold-rolled grain-oriented silicon steel, you get a smaller, lighter, quiet dry-type transformer designed for years of service.

The new transformers are quiet—All have sound levels equal to or less than NEMA Standards. The rigid welded design of the units helps eliminate lamination vibrations, and on the larger units, built-in rubber mountings reduce noise transfer through conduits and mounting brackets.

Complete stocks of the new transformers are available at local electrical distributors. Single-phase units are built for applications through 167 kva and three-phase ratings are available up to and including 500 kva.

It will pay you to investigate how you can save on installation costs, get customer satisfaction, and be competitive, with General Electric's complete new line of quiet QHT dry-type transformers. Section 411-8, General Electric Company, Schenectady 5, New York.

*Quiet, High Temperature dry-type transformers.

GENERAL ELECTRIC

SECTION A411-8
GENERAL ELECTRIC COMPANY
SCHENECTADY 5, NEW YORK

Please send me the new Buyers Guide, GEC-1047.

NAME .....

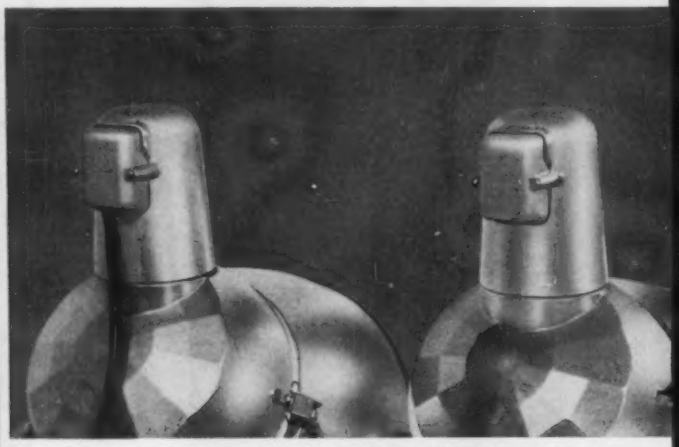
TITLE .....

COMPANY .....

ADDRESS .....

CITY ..... ZONE ..... STATE .....

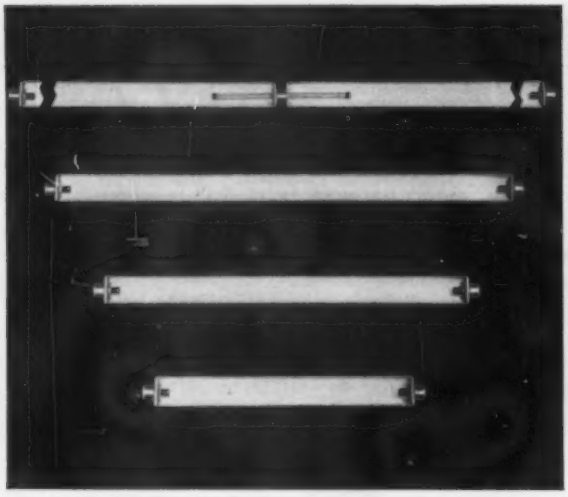
MERCURY Now, 100- to 1000-watt mercury lights give twice the light per watt, 2 to 6 times

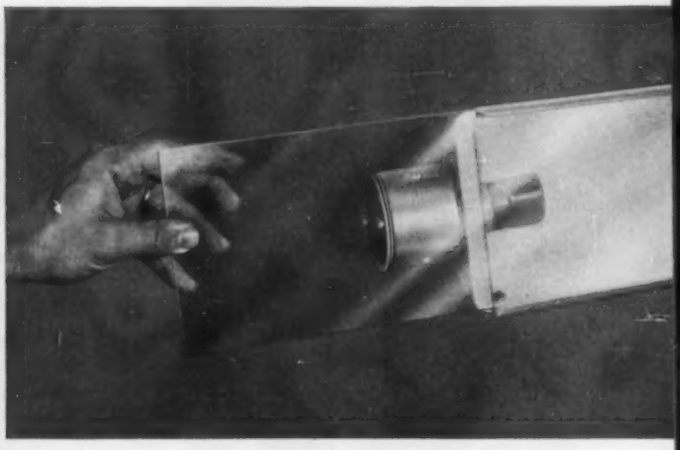


Wired or unwired—get the L-69A prewired, with 4-foot cable, or buy it unwired—to cut cost and splicing time.

FLUORESCENT Fluoroflood* fixtures are available in 4-, 6-, 8-, or 9-foot lengths—for High

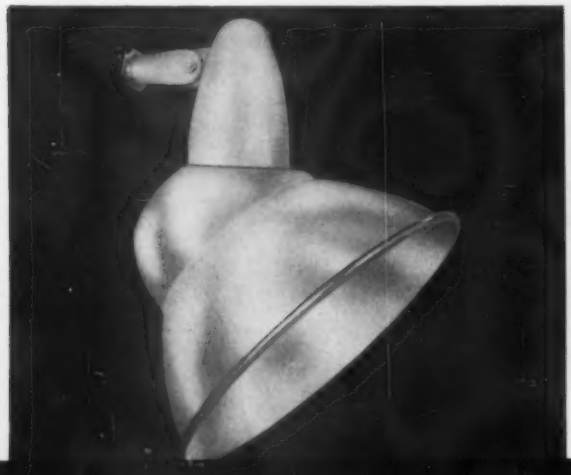
*Registered Trade-mark of General Electric Co.

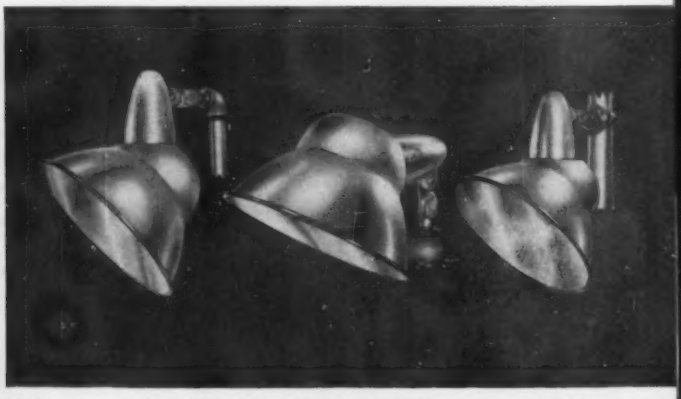




Cover slips out easily for simple relamping and maintenance—regardless of position of mounting conduit.

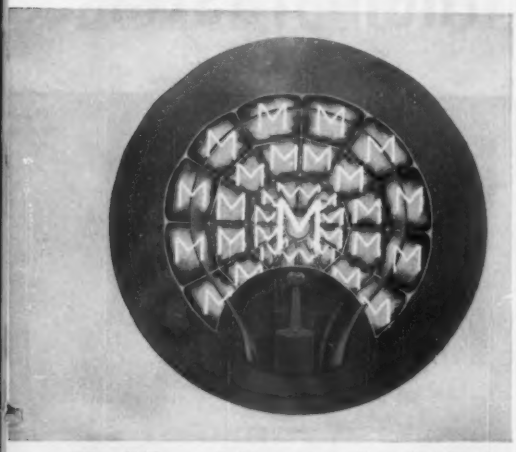
FILAMENT A complete line of filament floodlights—from 250 to 1500 watts, includes a model for





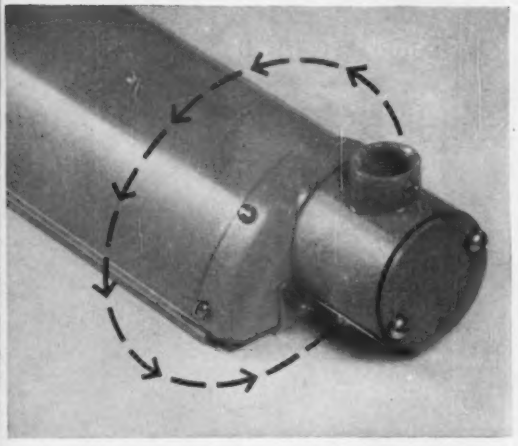
All angle mounting of L-100 and L-55 series (filament or mercury) made possible by threaded mounting stud and locknut.

longer lamp life than filament.



5% to 35% more light—more uniform distribution —with exclusive "diamond back" reflector.

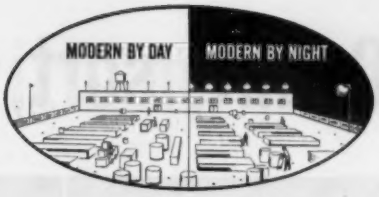
Output or Power Groove lamps.



360° rotation of reflector permits mounting at any angle, aiming in any direction.

almost any application.

Economy model—L-55 open floodlight—features faceted one-piece porcelain reflector.



Only with General Electric floodlights can you choose from ALL 3 LIGHT SOURCES and get these important benefits

More light per unit, better distributed light—For example the optical design of General Electric's Fluoroflood fixture is specifically designed to deliver maximum light in a uniform pattern, eliminating "hot spots" and dim areas. For filament or mercury lighting, G.E.'s exclusive "diamond back" reflector—featured on our L-69A, L-55, and L-100 units, delivers from 5% to 35% more light—light that is usually lost behind the lamp with ordinary fixtures.

Fast installation, practically no maintenance—Sturdily designed G-E floodlights are fast and simple to mount, aim, connect, and maintain. The external terminal box on the L-69A (mercury or filament) makes wiring faster and simpler, insulation life is increased many times. The Fluoroflood fixture offers easy access to wiring and complete flexibility in mounting and aiming. Since the reflector can be rotated 360°, you can mount it at any angle, aim it in any direction. Installation and maintenance are greatly simplified since the unit consists of only two end castings with lampholders and a reflector.

Availability from many distributors' stocks—Coast to coast, more than 500 electrical distributors are franchised to supply General Electric floodlights from stock or by prompt shipment. Remember, General Electric premium quality floodlights cost no more than ordinary floodlights.

Call in your G-E Distributor today for the complete story—or send in the coupon below.

GENERAL ELECTRIC

Section A450-14, General Electric Company, Schenectady, N. Y.

Please send me free information on the subjects checked below:

- ☐ Filament Floodlighting
- ☐ Mercury Floodlighting
- ☐ Fluoroflood Fluorescent Fixture
- ☐ Floodlighting Application Manual

Name _____

Company _____

Street _____

City _____ State _____

Count, sort, or inspect them faster

Self-contained relay

Low-cost; ideal for limit-switch-type application; includes a SP-DT output relay.

Transistorized relay

Features transistors; hermetically sealed plug-in relay; miniature light source, photocell holders.

General-purpose relay

A low-cost, highly reliable relay suited to counting, diverting, limiting and signalling jobs.

Explosion-proof relay

Watertight, explosion-proof; includes 3-inch lens, self-contained phototube, time delay.

Long-distance relay

Responsive *only* to light from accompanying light source; operates at distances up to 2,500 feet.

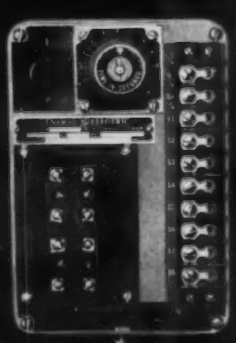
Smoke-density indicator

Measures smoke density, liquid turbidity, etc., and provides alarm when pre-set point is reached.

Voltage-sensitive relay

Detects voltage changes for meter operation, elevator-motor overspeed detection.

Electronic timer



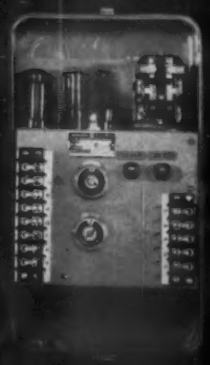
Provides time delay of given duration, or set interval simply by setting dial at desired time.

Cut-off register control

Low-cost; features direct operation of solenoid, small scanner, timed reset and relay kits.

and more efficiently with modern

High-speed relay

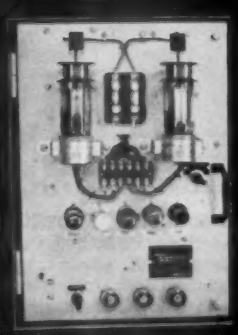


High-sensitivity; fast operating (600 ops. per min.); time delay, interlock, many other features.

Resistance-sensitive relay

Uses resistance changes to control a circuit; can operate motor to maintain liquid between two levels.

Side-register control



Accurately maintains lateral position of moving web in a process or machine; high-accuracy control.

G-E electronic devices

Your General Electric distributor offers a full line of simple, easy-to-use controls

Whether you're automating a production line . . . replacing obsolete machines . . . or, trying to get more out of present equipment . . . one of General Electric's photoelectric or electronic controls may help you gain faster, more efficient production.

Why? Because G-E photoelectric and electronic control devices are specifically intended to take the complexity . . . the labor . . . and the waste out of modern-day production. Combinations of these devices are applicable to virtually any industrial counting, sorting, signalling, protecting, diverting, detecting, or limiting job. And, chances are they will do the job at less initial cost—and lower operating cost—than the control methods you are now using.

CONSIDER THESE EXTRA-VALUE FEATURES

Bonus features you get with job-proved General Electric photoelectric and electronic controls include:

Fast response—Relays operate on light changes as short as 1/1000th of a second.

Versatility—G-E relays operate on light increase, decrease, time delay, reflected light, slow or rapid light change.

Dependability—Lamps operate 3,000 hours or more. Components are conservatively rated for long, maintenance-free life.

If you are not satisfied with the efficiency of your production operations, it will pay you to find out about G.E.'s complete line of control devices. Call your nearby G-E Apparatus Sales Engineer or Distributor. Or, send us the coupon below. *General Electric Co., Specialty Control Dept., Waynesboro, Va.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

SEND TODAY FOR *FREE* CATALOG

General Electric Co., Section A793-1
Schenectady 5, N.Y.

Please send me a copy of the new G-E Photoelectric Control catalog, GEA-6822, with description, specifications, and pricing data on the complete line.

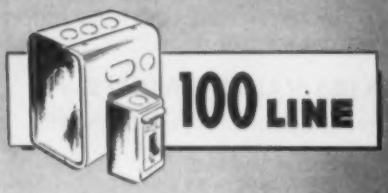
Name _____

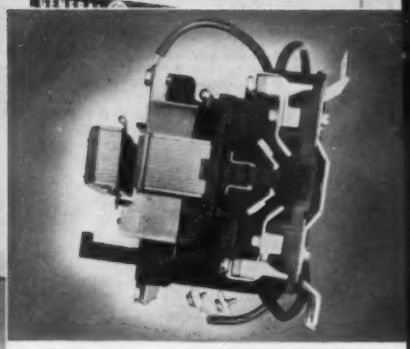
Company _____

Address _____

City _____ **State** _____

NOW AVAILABLE IN GENERAL ELECTRIC'S





WEDGE-ACTION DESIGN (see cross-section cutaway) gives positive "make." A quick, clean "break" is assured by spring-loaded contacts and a low-stress "kick-off" spring.

FIELD-PROVED 100-LINE DESIGN . . .

NEW SIZE 2 MAGNETIC STARTER

General Electric now offers a Size 2 magnetic starter that is 34% smaller than previous open forms, and includes all the field-proved features of General Electric's 100-Line. You get better performance, less maintenance and greater dependability because:

WEDGE-ACTION CONTACTS provide more positive "make". Reduced armature mass and spring-loaded contacts practically eliminate bounce. Contact springs and a special "kick-off" spring provide positive "break". Vertical contacts shrug off dirt and dust.

NEW ARC TRAP DESIGN actually attracts arcs away from contacts and dissipates them harmlessly to prolong contact life.

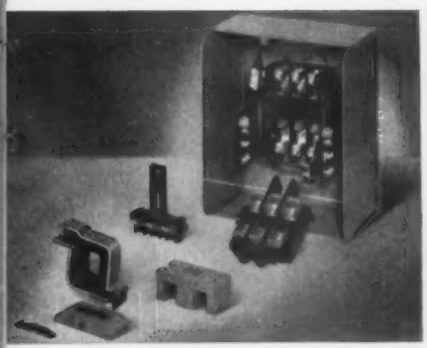
SNAP-SLIDE CONSTRUCTION makes possible complete disassembly of the starter in 20 seconds. Contacts can be removed and inspected in ten seconds.

STRAIGHT-THROUGH WIRING means no wires need be bent or looped, and all wiring is done from the front. Pressure-type terminals and 10% more wiring room speed installation.

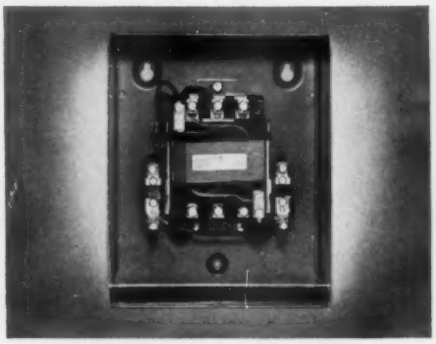
For more information, contact your nearest General Electric Apparatus Sales Office or Distributor, or write Section 733-45, General Electric Co., Schenectady, N. Y. (Ask for Bulletin GEA-6917.)

RUGGED DEPENDABILITY of new General Electric Size 2 starter is proved by severe plugging-duty torture test.

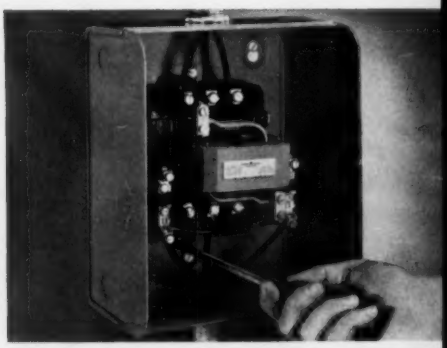
GENERAL ELECTRIC



SNAP-SLIDE CONSTRUCTION permits complete starter disassembly in 20 seconds without tools. All operating parts either snap or slide together for maximum accessibility.



10% MORE WIRING ROOM makes the new Size 2 starter easier to wire, even though it is 14% smaller than previous enclosed forms. Wrap-around cover adds extra accessibility.



STRAIGHT-THROUGH WIRING with line terminals on top and load terminals on bottom saves wiring time. All wiring is done from front, and no wires need be bent or looped.

How to cut costs with the RIGHT motor

Don't be baffled by power factors, torques, efficiencies, and starting, accelerating, and thermal characteristics, or housing, horsepower and speed control. Let Century Electric help you balance these factors to cut operating costs with the *right* motor.

Here's how Century Electric can help you:

10,000 choices—Century Electric engineers can help you specify the right motor without having to rely on a few types to do all jobs. Century Electric makes a complete variety of integral horsepower motors. Over 10,000 types up to 400 hp. There is one for every type of equipment—transfer machines, ball mill drives, compressors, drilling machines, lathes, etc. For all operating conditions too—dusty, corrosive, explosive or moist.

Long life motors—And you get years of dependable operation from Century Electric motors. They are manufactured to rigid quality standards. Electrical tests and other checks on operating characteristics made during manufacture assure you the best motor for your money.

Application know-how—Every Century Electric sales engineer knows motor drive systems because he sells motors and nothing but motors. Often he can give you on-the-spot answers. If not, he can turn to an engineering staff that comes up with quick answers.

You can get the right motor for your equipment just by contacting your nearest Century Electric Sales Office or Authorized Distributor. A Century Electric sales engineer will be glad to help you.

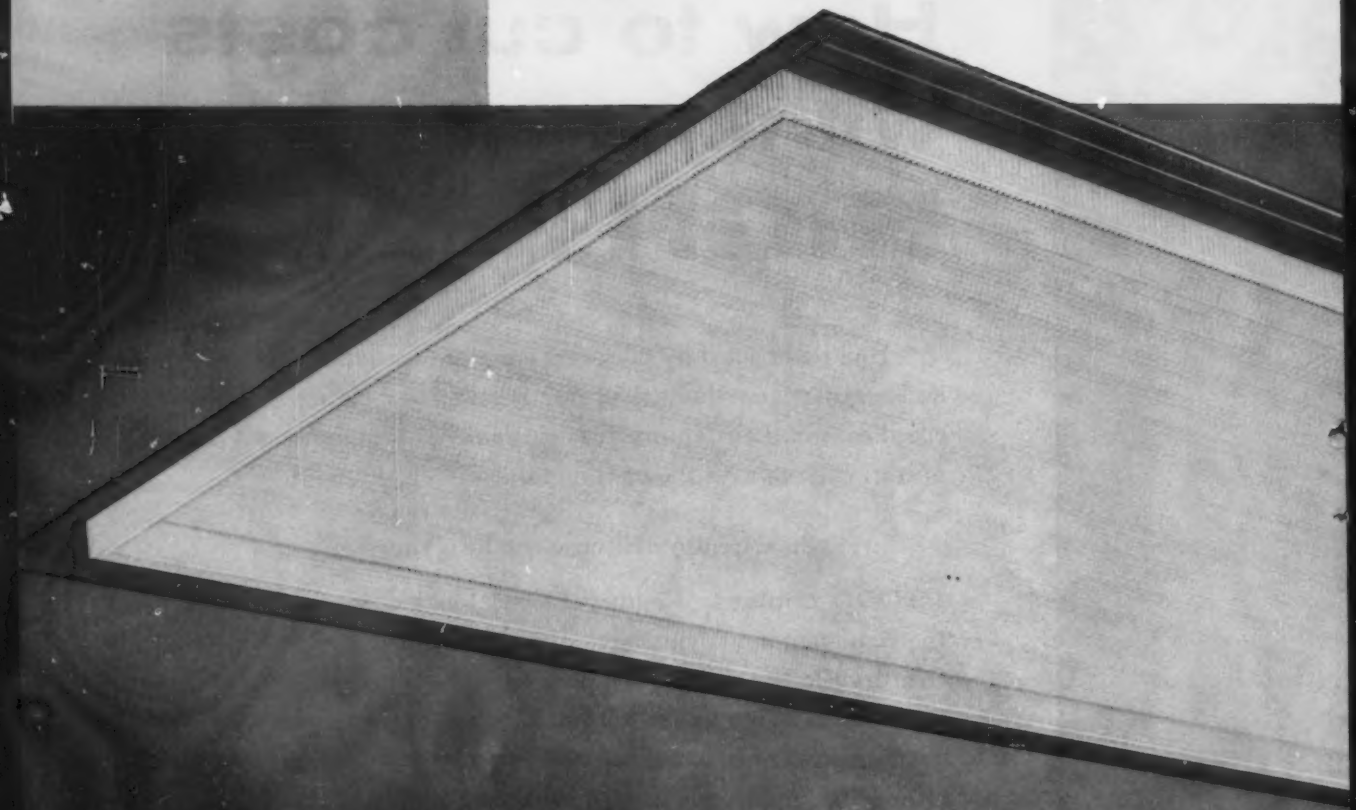
CENTURY ELECTRIC COMPANY

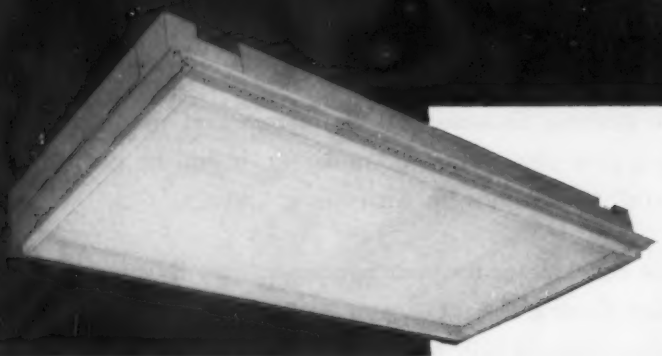
St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Century

58-22

From the Heritage of HOLOPHANE Craftsmanship...





Two Totally New Concepts...
2-Foot-Wide Installation...

HOLOFLUX recessed units, with many functional advancements, are available in 2 major styles. One employs a luminous prismatic border (as shown) for ceiling illumination. The other features flat CONTROLENS for unbroken ceiling surfaces . . . Basic units, in 4-foot lengths (2 or 4 lamps per section) are made for single or continuous run applications.

Exceptional Versatility...
Wide Range of Applications

HOLOFLUX satisfies the increasing demand for highly efficient, prismatically controlled, recessed lighting. Its distinctively simple, streamlined design integrates with a wide variety of contemporary interiors: stores, offices, showrooms, banks, public buildings, waiting rooms, sales offices, airport public areas, institutions. Recommended for today's low-ceiling installations.

HOLOPHANE COMPANY, INC. ECM
342 Madison Ave., New York 17, N. Y.

We'd like to learn more about your HOLOFLUX 6400 SERIES. Please send installation and engineering data, without obligation.

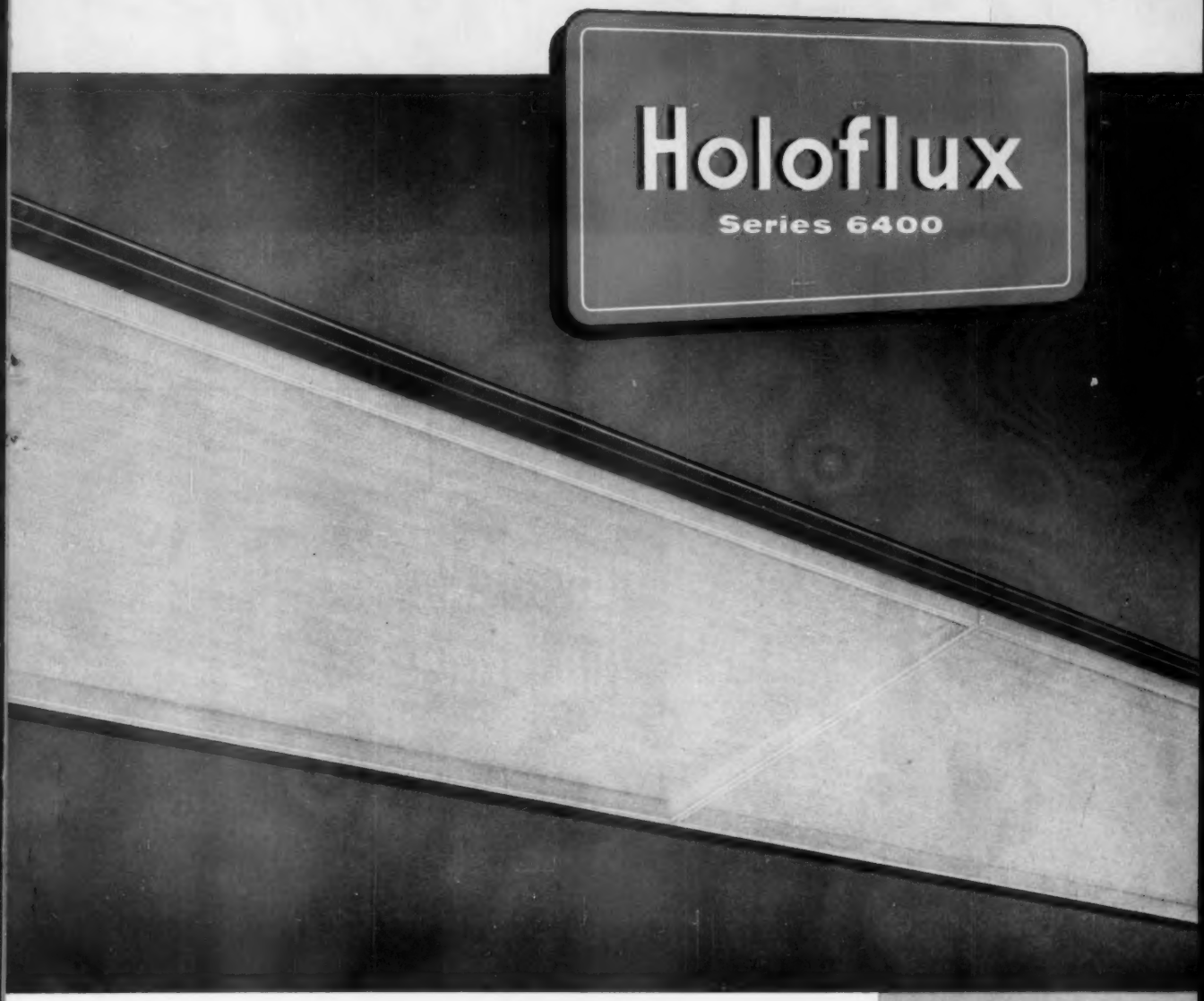
INDIVIDUAL _____

ORGANIZATION _____

STREET _____

CITY _____ ZONE ___ STATE _____

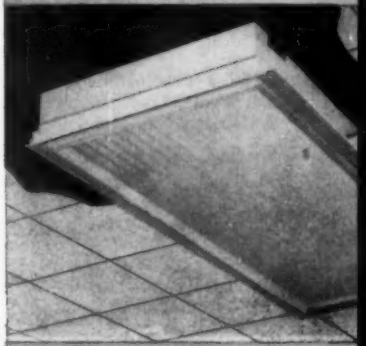
A Most Important ADVANCE in Recessed LIGHTING...



Here's the Future of Lighting—
Ready NOW...for Today's Interiors...

All the specialized skills and experience accumulated by HOLOPHANE through 61 years of lighting leadership have contributed to the development of this latest achievement—the new HOLOFLUX* family of luminaires... Unique illuminating advantages, never before available, are made possible by the PRISMALUME* (acrylic plastic) CONTROLENS*. These lenses are crystal clear, light in weight, shatter-resistant, and free from discoloration. They are molded to provide prismatic patterns that assure highest efficiency, lowest brightness, upward (ceiling) light... HOLOFLUX mechanical features: very shallow fixture; easy installation; great rigidity for continuous runs (no visible metal); positive action door; economical maintenance.

For all types of ceilings: Holoflux units are engineered for easy installation in all modern forms of ceilings, including the inverted "T", "Z" and "H" spline; also in the ordinary and acoustical plastic ceilings.

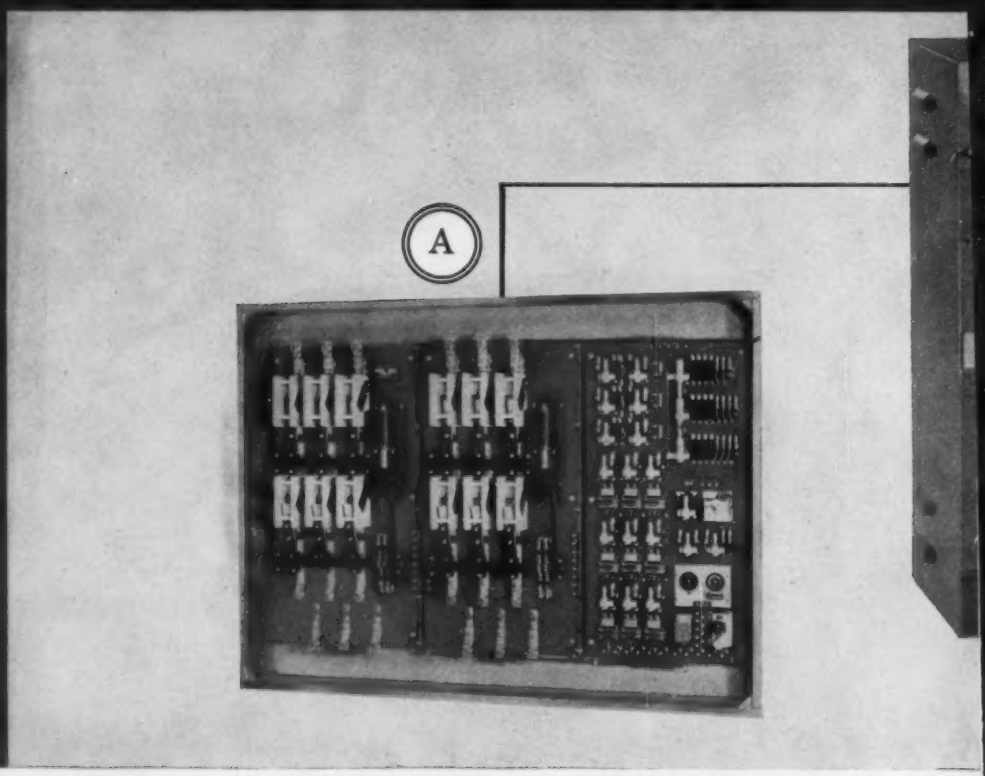


HOLOPHANE COMPANY, INC.
Lighting Authorities Since 1898
342 Madison Ave., New York 17, N. Y.
THE HOLOPHANE CO., LTD., 418 KIPLING AVE. SO., TORONTO 18, ONT.

*Trade Marks

WHEN POWER

ASCO COMPLETE CONTROL SYSTEMS PUT



Here's how ASCO control system operates . . .

ASCO Automatic Transfer Switches, with built in selected time delay of ½ to 3 seconds, ignore momentary outages caused by transient conditions—thus protect generating equipment from false starts. However, once a sustained outage is detected, ASCO Control Systems put standby power in action—fast. Follow the cycle, step by step . . .

STEP 1 The instant a sustained outage is detected, a contact on the ASCO Automatic Transfer Switch (A) closes.

STEP 2 This energizes the ASCO Automatic Engine Starting Control (B), which opens the fuel control device on the generator and cuts in batteries to energize the starting motor and crank the engine (C).

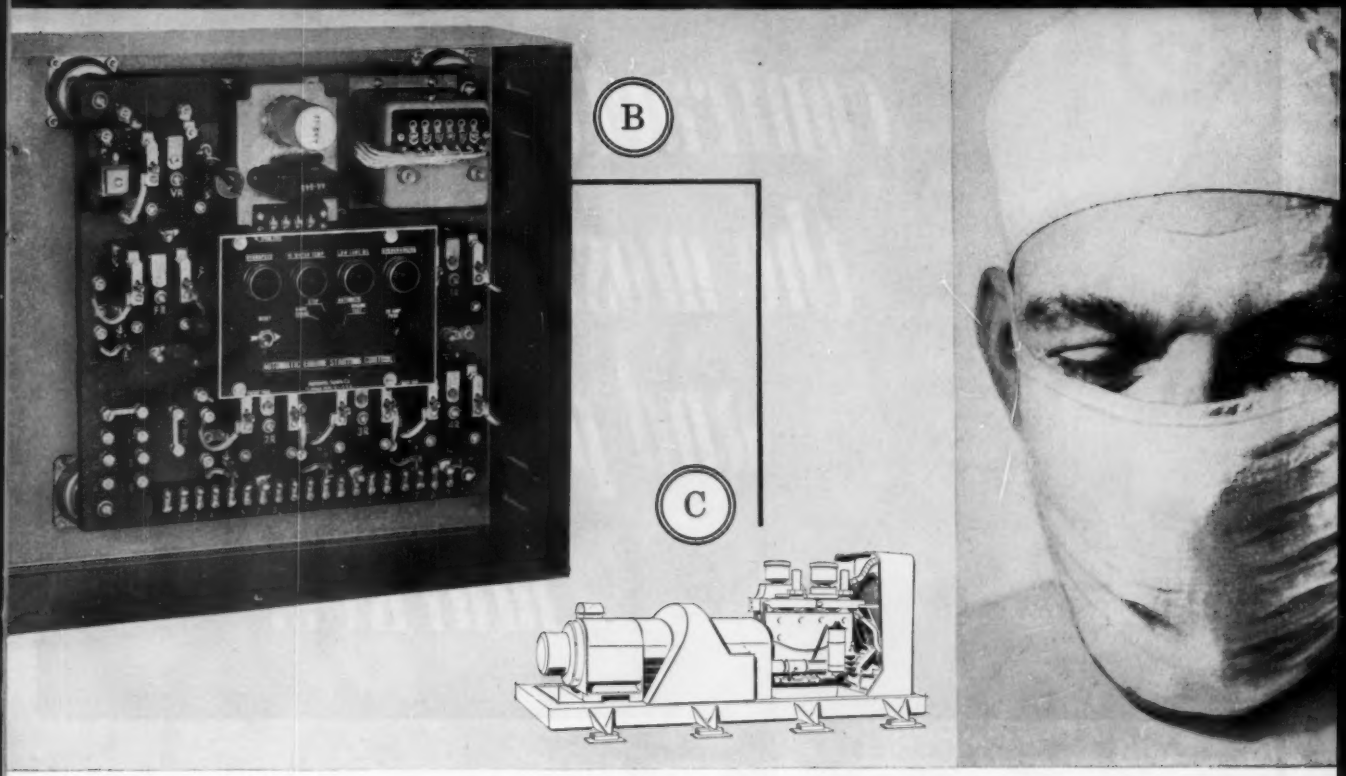
Four on-off cranking cycles are provided. When the engine fires, the starting control automatically disconnects the cranking control.

STEP 3 When standby power source reaches proper voltage and frequency, the transfer switch transfers the load to the electric plant. Time of transfer —1/30 to 1/6 of a second!

When normal power is restored, the ASCO Transfer Switch returns the load to its original feeder lines. The Starting Control then causes the electric plant to shut down.

FAILS...

STANDBY POWER IN ACTION – FAST



For Dependable Standby Power, ASCO designs and manufactures a complete line of emergency power and electric plant control equipment. In addition to Automatic Transfer Switches and Automatic Engine Starting Controls, this includes:

Solenoid Valves: For air starting applications, and for controlling the flow of cooling water, fuel oil and other liquids and gases.

Battery Chargers: To keep starting batteries charged, ready for engine starting.

Solenoids: For fuel control devices, operating shutters for engine cooling, and other electric plant applications.

Load Demand Controls: To automatically start engine when load is applied; stop it when load is removed.

For Detailed Information write for:

Catalog 57-S1 – Automatic Transfer Switches

Catalog 57-S5 – Solenoids

Catalog 57-S6 – Electric Plant Controls (including battery chargers)

Catalog No. 25 – Solenoid Valves

Dependable control by ASCO

Automatic Switch Co.

50-J Hanover Road, Florham Park, New Jersey • Frontier 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO®

Edwards helps contractors make the most of a big and profitable market!

If your signaling installations are limited to just bells and buzzers you've been missing sales opportunities that a profit-conscious organization can't afford to ignore. Modern signaling is *systems*—Edwards signaling systems primarily. These systems represent extensive, often elaborate installations that are definitely worth your while.

Edwards provides a complete line of equipment available through your local Edwards distributor for every type of signaling requirement in control, communication and protection—and the Edwards Technical Representative is always there to assist you on the more elaborate jobs. Remember, Edwards recommends the recognized electrical contractor as the sole installer of its equipment. Why not call your Edwards distributor today and start participating in this rapidly expanding market...

as a team effort!

POTENTIAL INSTALLATIONS	PROSPECT	SCHOOLS	INDUSTRIAL PLANTS	OFFICES	STORES	WAREHOUSES	HOSPITALS	RESIDENCES
Fire Alarm Systems	✓	✓	✓	✓	✓	✓	✓	✓
Clock Systems	✓	✓	✓	✓	✓		✓	
Clock & Program Systems	✓	✓	✓	✓	✓			
Paging Systems		✓	✓	✓	✓	✓	✓	
Intercommunication Systems	✓	✓	✓	✓	✓	✓	✓	✓
Burglar Alarm Systems		✓		✓	✓	✓	✓	✓
Psychopathic Alarm Systems							✓	
Nurses Call Systems							✓	
In & Out Registers		✓	✓				✓	
Annunciators		✓	✓	✓			✓	
Chimes	✓	✓	✓	✓	✓	✓	✓	✓
Bells	✓	✓	✓	✓	✓	✓	✓	✓
Buzzers	✓	✓	✓	✓	✓	✓	✓	
Horns	✓	✓	✓	✓	✓	✓	✓	✓
Push Buttons		✓	✓	✓	✓		✓	✓
Door Openers		✓						✓
Call Buttons	✓	✓	✓	✓	✓		✓	✓
Other Contact Devices	✓	✓	✓	✓	✓	✓	✓	✓

TEAR ON DOTTED RULE

Edwards Signaling Products for Control, Communication, Protection

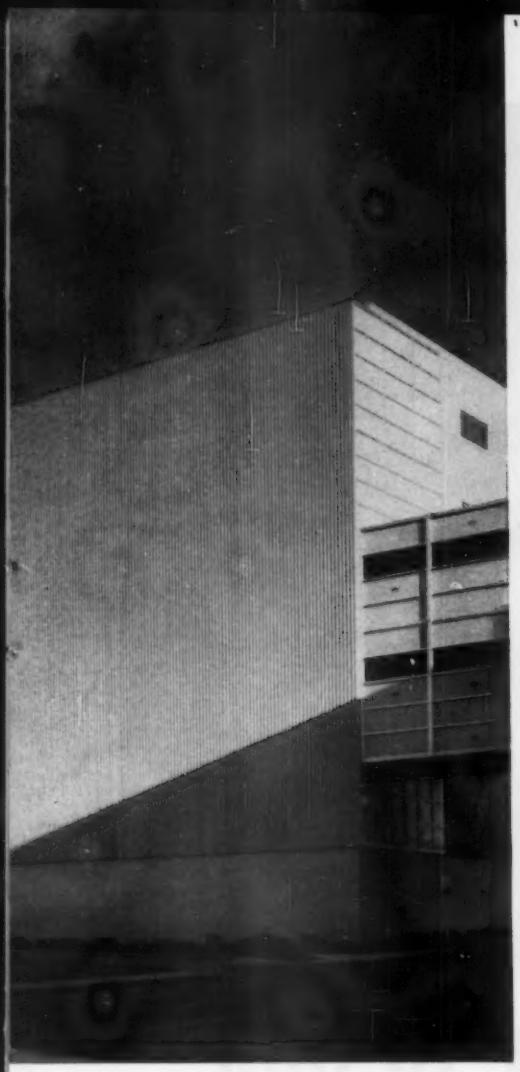
COMMERCIAL BLDGS.

Additional copies of this checklist are available direct from Edwards, write Dept. EC-5, Edwards Company, Inc., Norwalk, Conn. In Canada: Edwards of Canada, Ltd, Owen Sound, Ontario.

CONTROL • COMMUNICATION • PROTECTION **EDWARDS** *Specialists in signaling since 1872*

■ Hallmark Cards, Kansas City, Mo., where Curtis Visioneers "personalized" the illumination system in keeping with the products of the company. Architect & Consulting Engineer: Welton Becket.

■ Curtis Vari-Spots produce attractive lighting patterns in several lobbies of the Hallmark Cards building. Reception room shown is approximately 45 ft. by 45 ft. Vari-Spots are used here to accent two areas. Each is impressively dramatized.



■ General office. Curtis Alzak aluminum low-brightness troffers assure glare-free illumination throughout the area, combining visual well-being with visual charm.

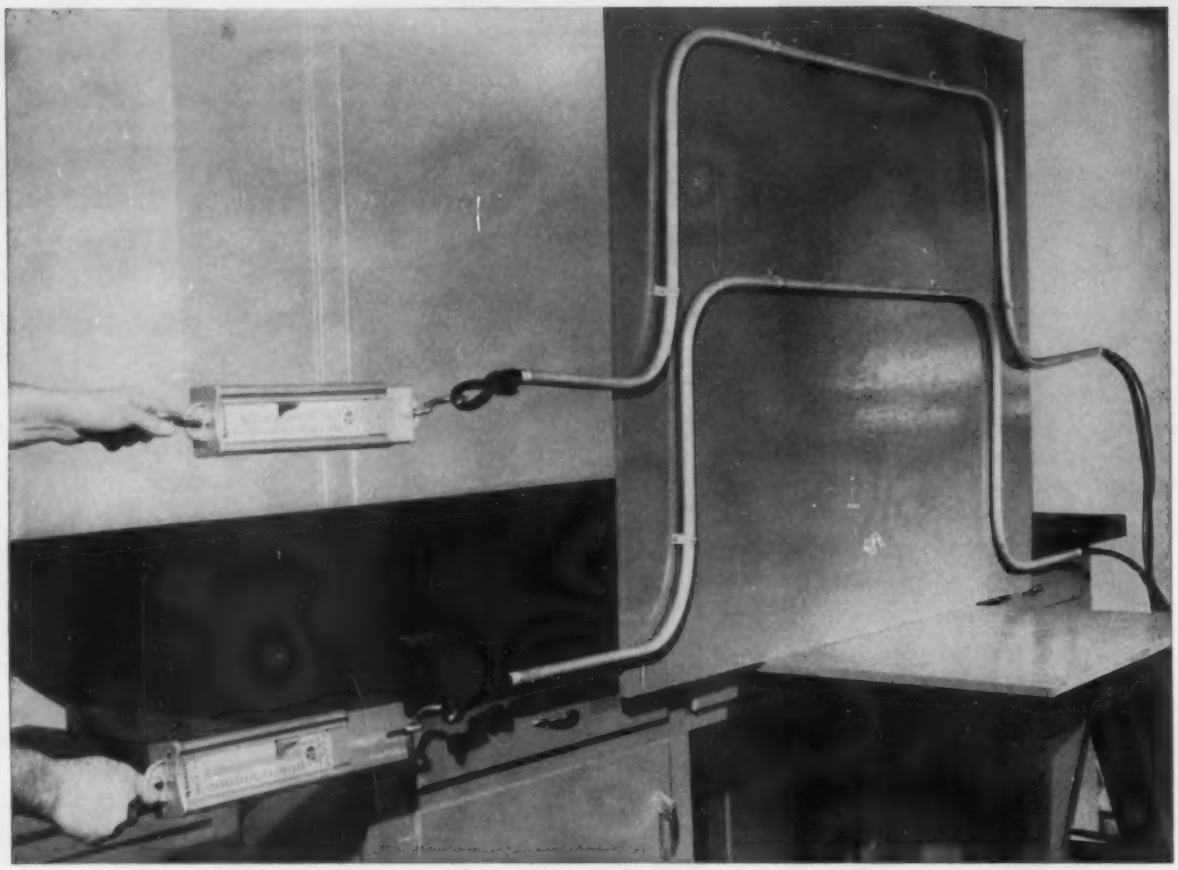
Curtis Lighting helps Hallmark Cards say "Welcome!"

Special illumination effects in greeting card building . . . accent high visual comfort . . . create a feeling of friendliness

It's only natural that a greeting card company would want to capture the spirit of its product in its headquarters building. And that was done at Hallmark Cards, Kansas City, Missouri. Technically, the lighting problem called for a system that would be uniform throughout the structure, yet provide the same glare-free illumination in rooms of various sizes. The assignment clearly prescribed Curtis Visioneering. The desired result was effected when Curtis designed a lighting system combining Curtis Alzak aluminum low-brightness troffers and Curtis Vari-Spot recessed incandescent units. The careful application of Curtis products completed the theme of visual charm and warm greeting, thus accentuating the aesthetic characteristics of the Hallmark Cards building. For assistance on your lighting problems write for the name of the Curtis Visioneer nearest you. Curtis Lighting, Inc., 6135 W. 65th Street, Chicago 38, Illinois. In Canada: 195 Wicksteed Avenue, Leaside, Toronto 17, Ontario.

CURTIS

Visioneers in Planned Lighting



Cables 50% easier to pull

with Rome's new invisible lubricant!

Two almost identical groups of wire of the *same* size were pulled through *identical* lengths of ½" conduit. *Yet, one group was 50% easier to pull!* Why?

An Actual Test

In the illustration above, you can see that the force needed to pull nine wires (No. 14 AWG) through the bottom section of conduit was approximately 150 pounds. These wires were coated with the conventional paraffin-type lubricant.

Now, note the top half of the test. Same *size* wires. Same *number* of wires. Same ½" *conduit*. But—*these* wires were coated with the new Rome Cable emulsion. Pulling force needed: Less than 75 pounds. Less than *half* the pulling force needed for paraffined wire. You can't see the coating—but, you *can* see the result, and it's permanently bonded to the insulation.

Easier Installations

This new improvement in wire coating can save money for you. With wire and cable pulling easier, you cut installation time and labor costs. There's no problem with the coating flaking off because it is virtually "married" to the insulation. Rome's new emulsion will not "pile up" to plug conduit or "freeze" cables in position.

Furthermore, extensive heating and aging tests have proved that this new emulsion coating will not be absorbed by the insulation, nor will it disappear through volatilization.

Available now

This new extra-low-friction coating is now standard on many of the Rome wires and cables which have Rome Synthinol insulation. A list of wires and cables coated with the new emulsion is shown at the right.

The next time you order building wire, be sure to ask your electrical distributor about Rome Cable's new emulsion-coated, easy-to-pull building wire.

New invisible lubricant now available on these Rome wires and cables:

- Rome Synthinol building wires and cables, Type TW—600 volts.
- Rome Synthinol 901 wires and cables for extra heat and corrosion resistance, Type TW—600 volts.
- Rome FlexAll cable, Types UF and NMC—600 volts.

324

ROME CABLE

CORPORATION

NEW SERVICE ENTRANCE EQUIPMENT

200-AMP CAPACITY... CIRCUIT BREAKER CONVENIENCE ... AT A COMPETITIVE COST

You will like the extra convenience of Heinemann's new 200-amp service entrance equipment . . . and so will your customers.

Trim, compact, smaller than comparably rated fused pull-outs, these units offer considerable savings in terms of easier installation and more efficient operation.

Installation features would make an apprentice happy. Wiring space is plentiful . . . connections are easily made with solderless screw-type connectors . . . knockouts are placed so that you can run-in conduit from any angle.

Completely non-thermal, the *magnetically* actuated Heinemann circuit breaker eliminates nusiance tripping and other temperature-caused troubles. You can therefore locate the unit wherever most convenient . . . next to heat lines or out in the hot sun, if necessary. The breaker will always carry full rated current, will always trip as specified.

Breaker protection provides other conveniences as well: no bothersome fuse changing, simplified switching: the switch handle has only two positions: ON and OFF. No reset position; no confusion possible.

Rated at 120/240V AC, two or three wire service, the new Heinemann service entrance equipment is available in outdoor or indoor enclosures. Both are of heavy-duty steel in a grey baked enamel finish. Outdoor enclosures are raintight, with hinged covers that may be padlocked against tampering.

You'll be pleasantly surprised by the cost. It's little more than that of comparably rated fused equipment.

For full information send for Bulletin 1003

HEINEMANN
ELECTRIC COMPANY
132 Plum Street, Trenton, N. J.

Circuit breakers

S.A. 1959

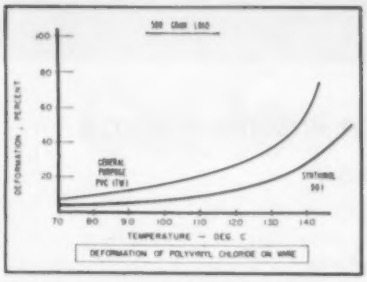
Advertisement

Troubled with wiring?

If so, consider the record being established by Rome Synthinol 901, a special 90° PVC compound for wire insulation and sheathing. It has helped to solve an impressive list of difficult wiring problems.

Developed by Rome Cable's laboratory and first introduced in 1949, Rome Synthinol 901 has proved by test and actual use to be superior to conventional PVC compounds in the following ways:

a. Suitable for continuous operation at higher temperature (90°C).
b. More stable under severe heat cycling.
c. Suitable for continuous immersion in hot transformer oil.
d. Superior resistance to chemicals and solvents.
e. Greater resistance to heat deformation.



Graph shows heat deformation vs. temperature, and compares Synthinol 901 with conventional PVC compounds. Test run in accordance with Underwriters' Laboratories standard procedure, except for temperature.

The practical value of this compound can best be illustrated by describing a number of actual case histories.

(1) Oil refinery, industrial and chemical plant wiring.

Plant and oil refinery engineers have long used conventional PVC insulations for plant wiring with good results, but too often heat deformation problems arose in warm locations. Since Rome Synthinol 901's superior deformation resistance suggested that it might be the answer to this problem, it was tried and soon became widely used because of its much better service record.

Synthinol 901 also proved to be far superior to conventional materials for chemical plant wiring where the corrosive action of chemicals and solvents has always been a tough problem. Although polyvinyl chlorides as a class have inherently better resistance to chemicals and solvents than many other materials, some engineers desired even further improvement. One user decided to test a number of samples over a long period by immersing them in various concentrations of acetone, different alkalis, and butyric, propionic, and acetic acids. The results of this careful evaluation showed clearly that, when exposed to these chemicals, Synthinol 901 would last longer than any other PVC tested.

(2) Oil-filled transformers.

Transformer engineers have long sought a cable construction to replace varnished cambric-insulated cable for leads in oil-filled transformers. These leads connect transformer windings and bushings and are constantly immersed in hot oil. One transformer manufacturer, encouraged by successful experience with Synthinol 901 on other applications, undertook a comprehensive study of the possible usefulness of this insulation in lieu of varnished cambric for high-voltage transformer leads. This study extended over a several-year period and proved to those engineers involved that there were at least four reasons for standardizing on Synthinol 901 for this application:

a. There was less sludge in the oil than when VC insulation was used.
b. There was no harmful degradation of the electrical properties of the oil.
c. Conductors insulated with Synthinol 901 ran cooler, permitting a 7% increase in lead cable current rating.
d. The use of Synthinol 901 in lieu of VC would permit substantial dollar savings.

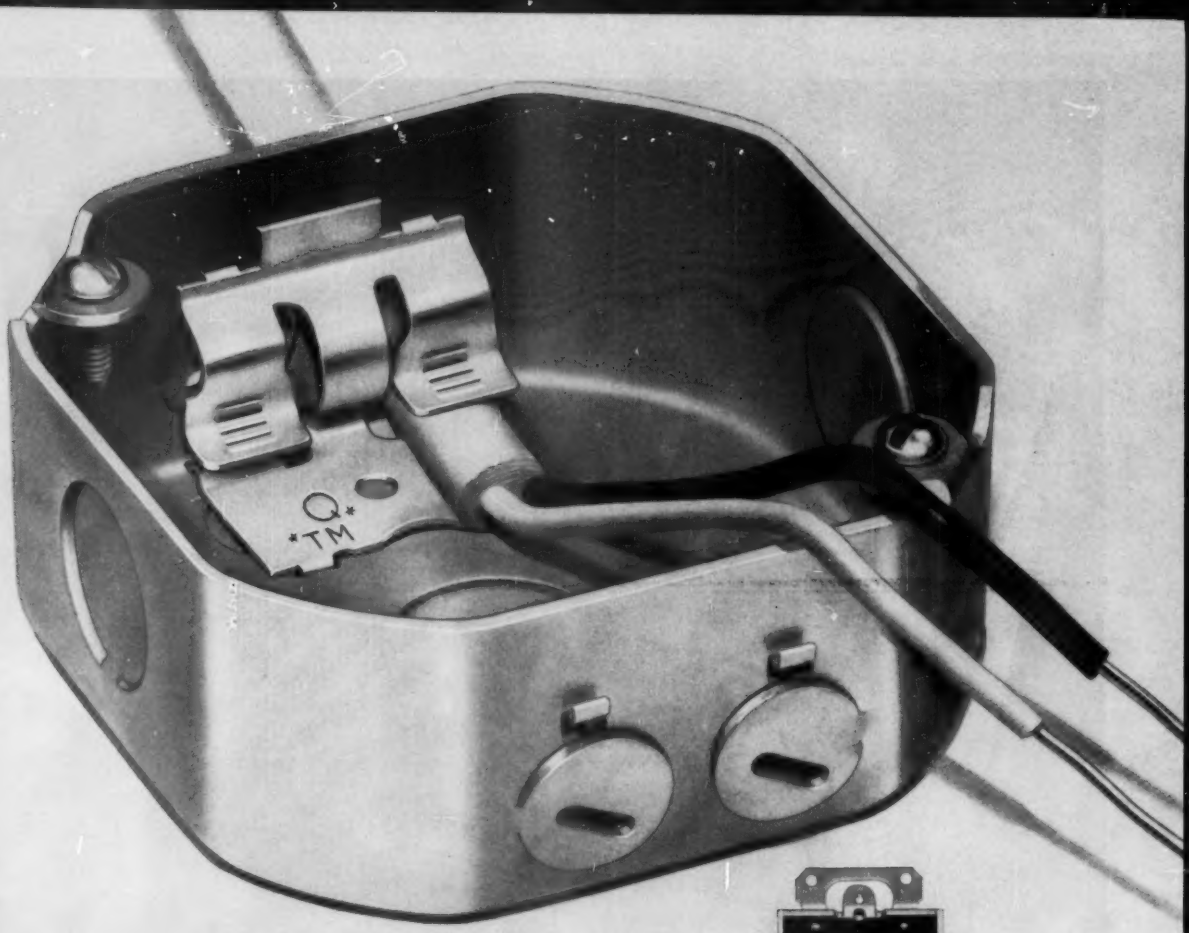
(3) Coil leads.

Many manufacturers of small coils for relays, small transformers, small motors, and electronic components have tried to use PVC insulated lead wires for many years. Typically, these leads are crimped or soldered to the ends of the coil; and the whole coil is then impregnated with varnish or wax and baked as long as 16 hours at temperatures as high as 150° C. The varnish used may be asphaltic, phenolic, alkyd, etc.; and the wax may be paraffin, beeswax, carnauba, or another kind.

PVC insulated lead wires frequently produced serious production problems because of the insulation's tendency to shrink, crack, and stiffen during the impregnation and subsequent baking period. Synthinol 901 was substituted in place of the ordinary PVC insulation and, after nearly eight years of wide usage, not a single case of shrinkage, cracking, or stiffening of insulation involving Synthinol 901 has been brought to our attention.

These case histories describe just a few of the applications for which Rome's Synthinol 901 has proved especially effective. Perhaps they will suggest other applications in your own area which might also be better handled with Rome Synthinol 901 instead of a conventional PVC compound. If you have a wire or cable problem that might be solved with Rome Synthinol 901, why don't you get in touch with us? Contact your nearest Rome Cable representative for more information—or write to Department 322, Rome Cable Corporation, Rome, N. Y.

ROME CABLE
CORPORATION



New RACO "Q"* Quick-Clamp can save hours on the job

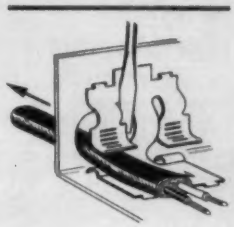
With RACO's New "Q" Quick-Clamp you can install non-metallic sheathed cable in seconds. Simply push the cable through "Q" Quick-Clamp. Cable is held firmly in place, can't be pulled out until clamp is released. To release the cable, apply a little pressure under the clamp with your screwdriver. With the new "Q" Quick-Clamp there will be no more lost time tightening and loosening cable clamp screws . . . no more stripped screw threads.

And . . . you'll save an hour or more on the average job (60 to 100 boxes per house). Your RACO Distributor has the New "Q" Quick-Clamp Switch and Outlet Boxes. They're revolutionary, yet so simple to operate. (Exceed Underwriter Laboratories' tests; are fully protected by patents.) See them and try them now.

*Trademark

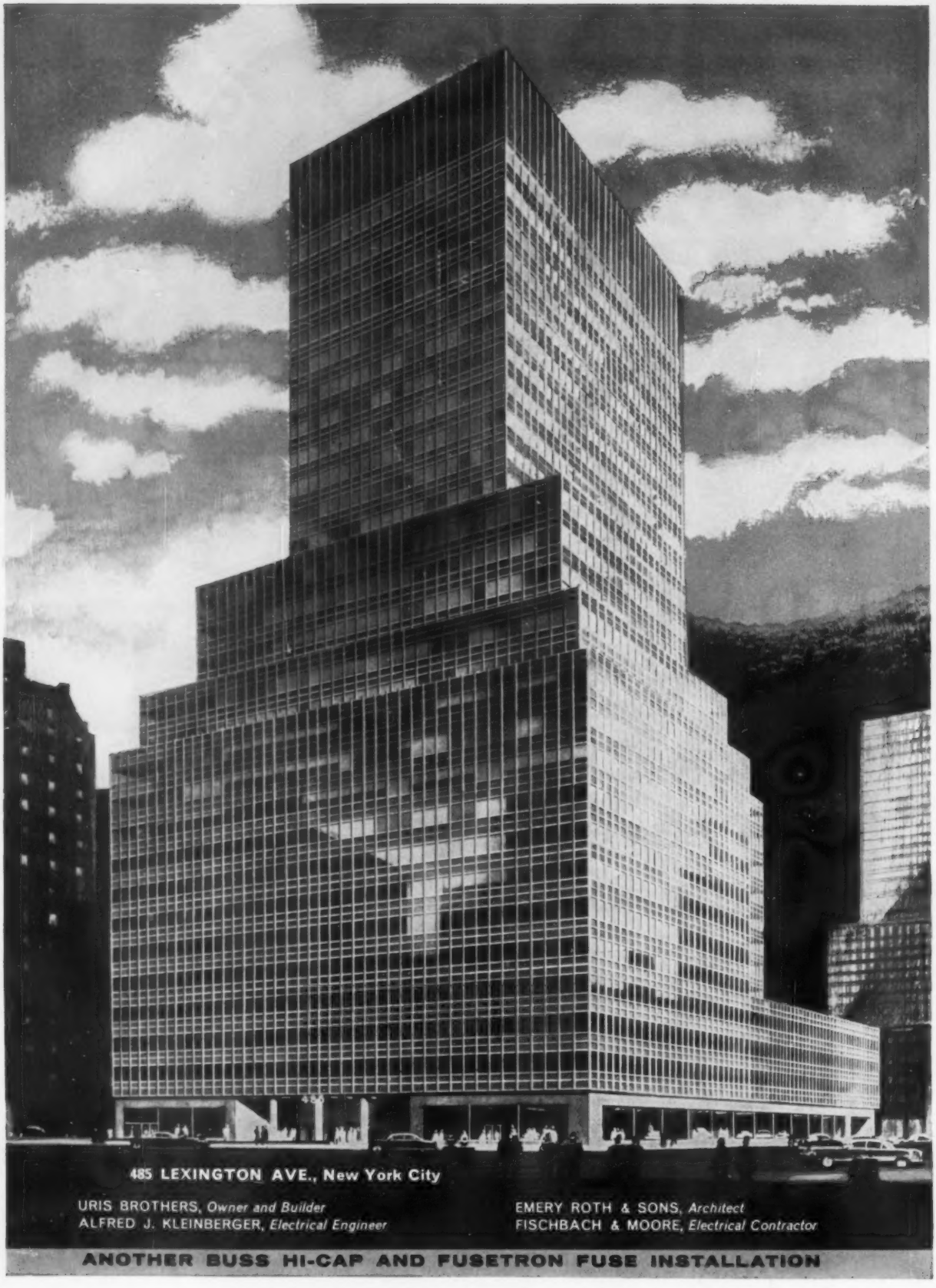
"Q" Quick-Clamp available in RACO switch or outlet boxes

Cable moves freely into clamp and is gripped tightly



To back-off cable, release clamp pressure with screwdriver

ALL-STEEL EQUIPMENT INC. Aurora, Illinois

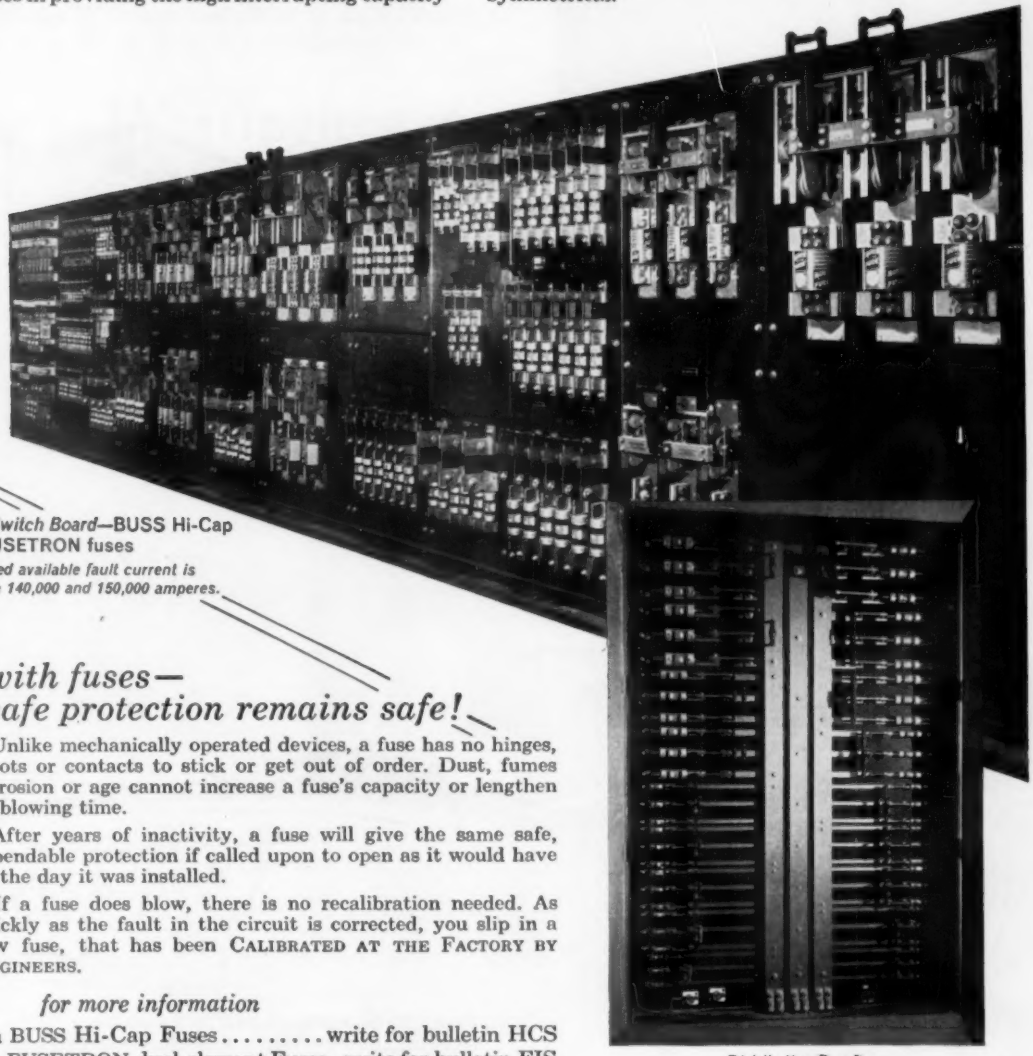

485 LEXINGTON AVE., New York City
URIS BROTHERS, Owner and Builder
ALFRED J. KLEINBERGER, Electrical Engineer
EMERY ROTH & SONS, Architect
FISCHBACH & MOORE, Electrical Contractor
ANOTHER BUSS HI-CAP AND FUSETRON FUSE INSTALLATION

Electrical Protection goes MODERN *with* BUSS Fuses at 485 Lexington Ave., New York, N.Y.

In keeping with the modern trend the electrical protection for this new 30 story office building is BUSS Hi-Cap and FUSETRON dual-element fuses.

No other type of protective device can match fuses in providing the high interrupting capacity and dependability required for today's circuits.

BUSS Hi-Cap fuses have a NEMA interrupting rating of 200,000 amperes rms symmetrical. FUSETRON dual-element fuses have a NEMA interrupting rating of 100,000 amperes rms symmetrical.



Main Switch Board—BUSS Hi-Cap *and* FUSETRON fuses

Estimated available fault current is between 140,000 and 150,000 amperes.

with fuses— safe protection remains safe!

Unlike mechanically operated devices, a fuse has no hinges, pivots or contacts to stick or get out of order. Dust, fumes corrosion or age cannot increase a fuse's capacity or lengthen its blowing time.

After years of inactivity, a fuse will give the same safe, dependable protection if called upon to open as it would have on the day it was installed.

If a fuse does blow, there is no recalibration needed. As quickly as the fault in the circuit is corrected, you slip in a new fuse, that has been CALIBRATED AT THE FACTORY BY ENGINEERS.

for more information

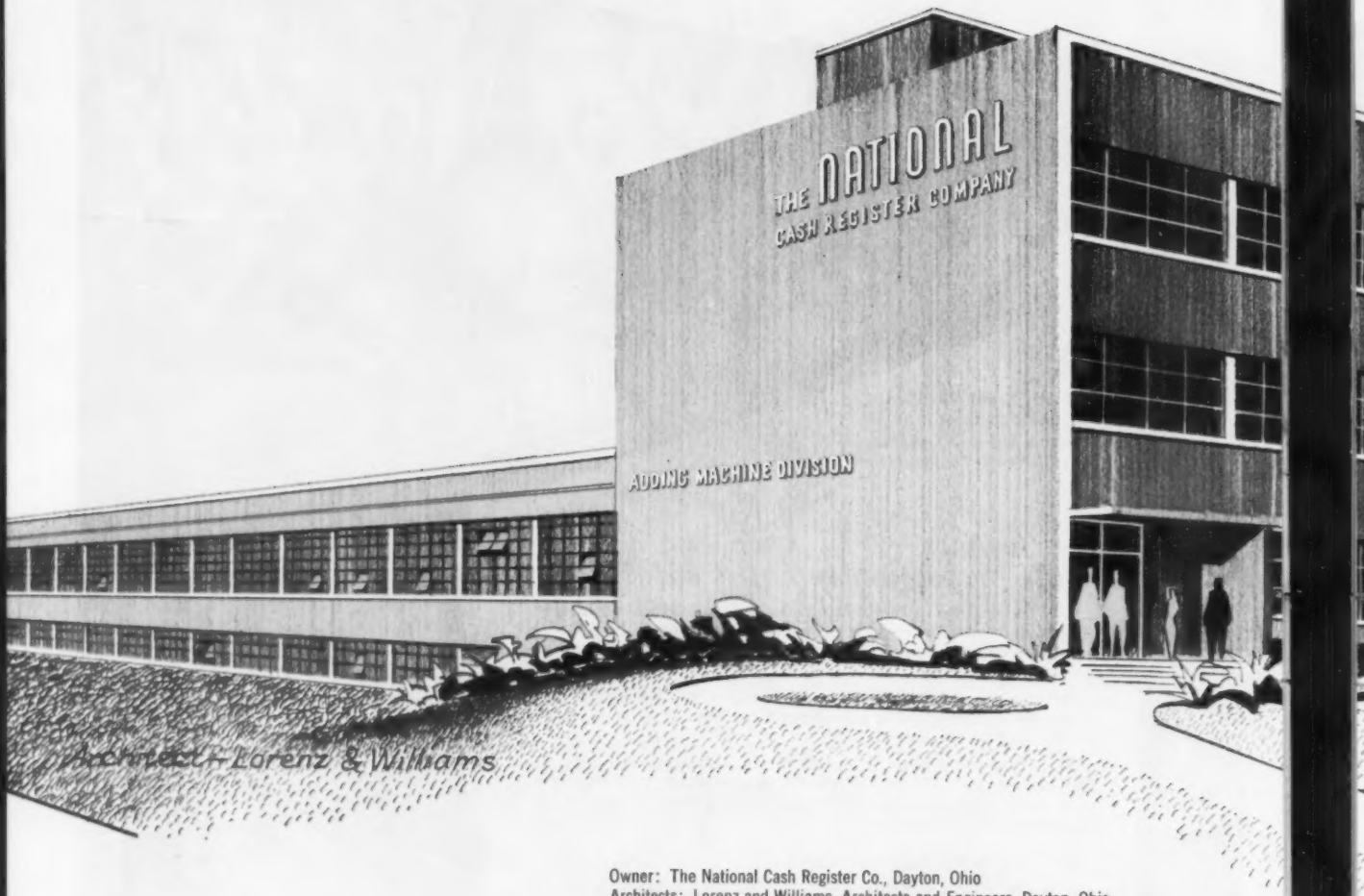
On BUSS Hi-Cap Fuses..... write for bulletin HCS
On FUSETRON dual-element Fuses..write for bulletin FIS

Distribution Panels
PROTECTED BY FUSETRON FUSES

659

BUSSMANN MFG. DIV., McGRAW-EDISON CO., ST. LOUIS 7, MO.

Panelboard planning helps Power-Up The National Cash Register Plant



Owner: The National Cash Register Co., Dayton, Ohio
Architects: Lorenz and Williams, Architects and Engineers, Dayton, Ohio
Consulting Engineer: Schweiger, Heapy & Associates, Dayton, Ohio
General Contractor: Streeter Associates, Inc., Elmira, N. Y.
Electrical Contractor: Buffalo Electric Co., Inc., Buffalo, N. Y.
Westinghouse Distributor: Buffalo Electric Co., Inc., Buffalo, N. Y.

An all-Westinghouse electrical distribution system meets all requirements

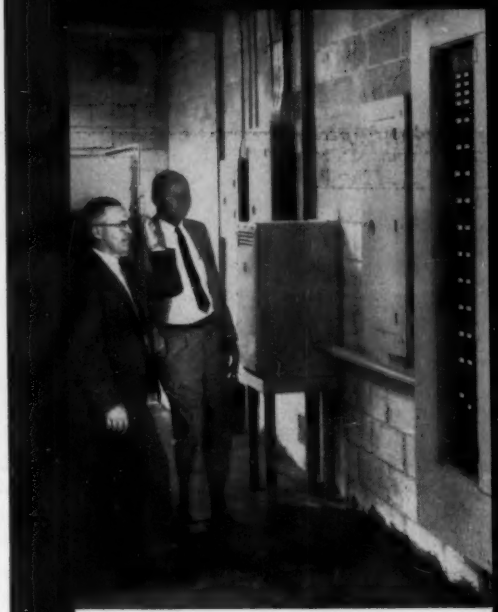
The new Adding Machine Division Plant of The National Cash Register Company in Ithaca, New York, was carefully planned to provide for efficient production and future plant expansion. Completely Westinghouse equipped, this new plant has a 50% reserve electrical capacity that can be utilized readily with the spare equipment now installed.

Westinghouse works closely with you in planning for future and present electrical needs, and in providing flexible and efficient systems that can be adapted to any changes in your production methods. Find out how Westinghouse Power-Up planning can increase the efficiency of your installation. Contact your nearby Westinghouse office, or write: Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa.

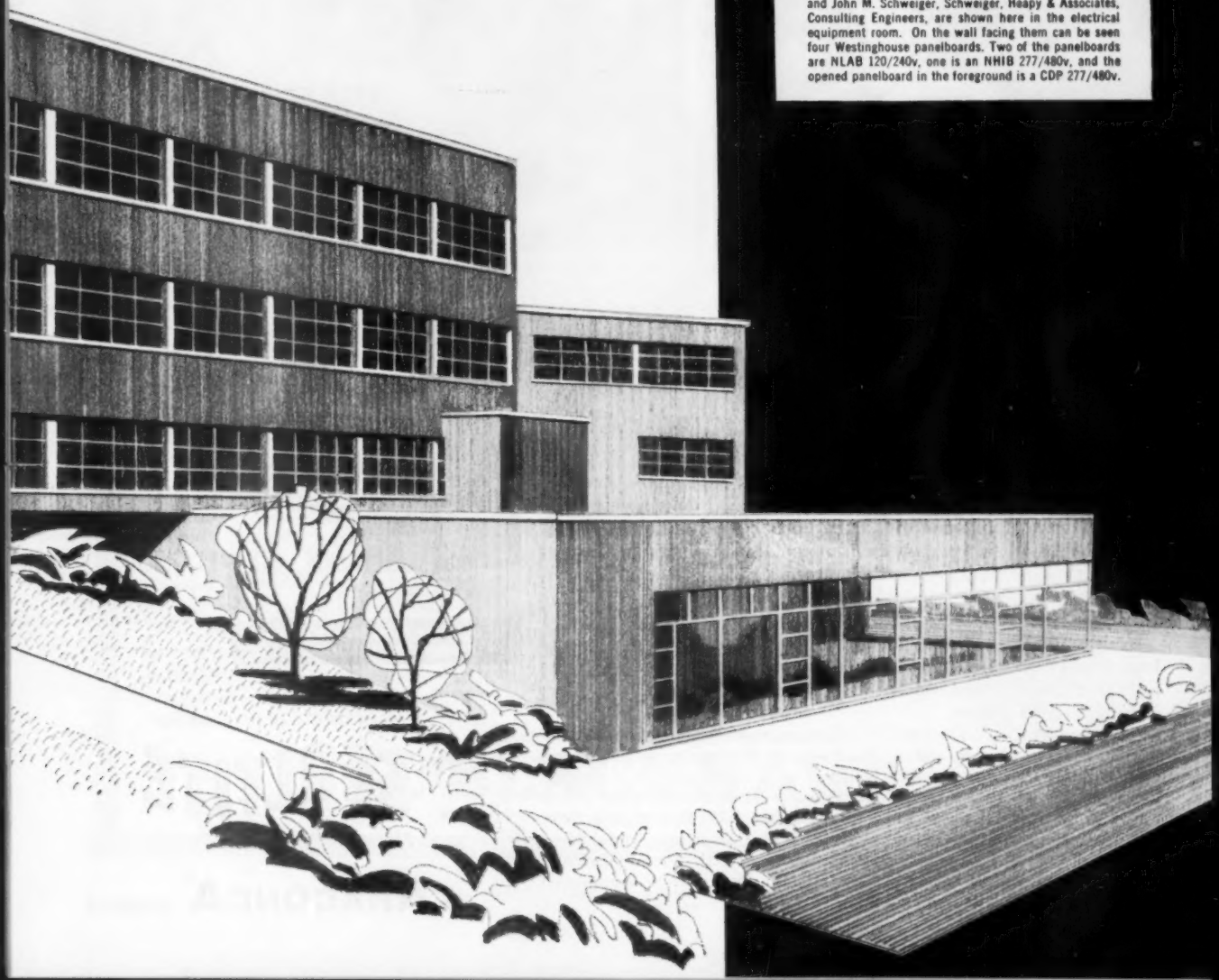
J-93549

YOU CAN BE SURE...IF IT'S Westinghouse

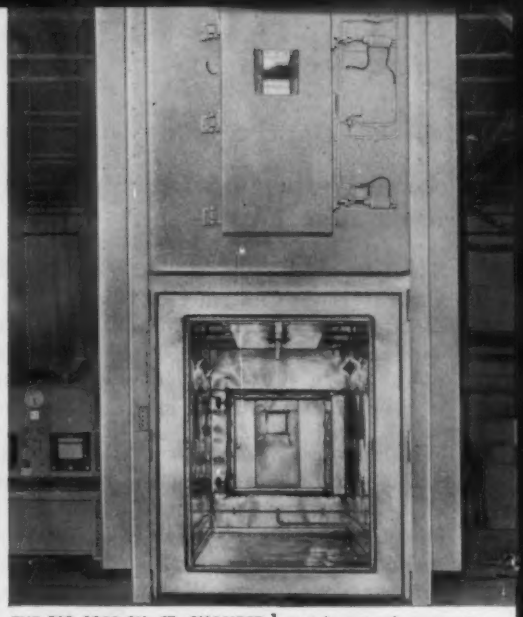
WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS



Clair Dean, Buffalo Electric Co., Electrical Contractors, and John M. Schweiger, Schweiger, Heapy & Associates, Consulting Engineers, are shown here in the electrical equipment room. On the wall facing them can be seen four Westinghouse panelboards. Two of the panelboards are NLAB 120/240v, one is an NHIB 277/480v, and the opened panelboard in the foreground is a CDP 277/480v.



WIRING TO PANIC SWITCHES outside a big walk-in altitude-temperature test chamber recently built by Conrad, Inc., Holland, Michigan, for a leading missile manufacturer is protected by Sealtite Flexible Conduit—which also simplified installation.



THE BIG 1200-CU. FT. CHAMBER has a temperature range of from 650F to minus 120F—can simulate altitude conditions from sea level to 120,000 ft.

MOTOR CONNECTIONS to the two 25-hp vacuum pumps are guarded by Sealtite Flexible Conduit. Pumps maintain a vacuum as low as 3.5 millimeters of mercury to simulate atmospheric conditions at high altitude.

CONNECTIONS TO THE FOUR 50-hp refrigeration compressors are protected by Sealtite Flexible Conduit. Two of the compressors operate with Freon 22 cooling the condensers of the two Freon 13 systems. This Conrad patented cascade design can readily produce temperatures to −120 degrees F.

TO HELP KEEP SPACE-AGE TEST UNITS WORKING FULL TIME, SEALTITE FLEXIBLE, LIQUID-TIGHT CONDUIT PROTECTS WIRING

Environmental test equipment must be more dependable than the item being tested. Time is critical in research and development programs. Conrad, Inc., which built the unit above, specializes in producing the highest quality environmental test chambers. Every means at its disposal is used to insure dependable equipment performance. To protect vital electrical connections it uses Sealtite Flexible, Liquid-Tight Conduit.

Sealtite has a tough, extruded polyvinyl jacket that provides protection even in roughest conditions. It's easier and less costly to install—it's ideal where conduit must flex or move, absorb vibration, join misaligned outlets.

WHERE TO GET SEALTITE—Electrical Wholesalers stock Types U.A. and E.F.* Sealtite in easy-to-handle coils, in black or gray. Be certain you ask for and get the quality conduit marked "Sealtite" and "Anaconda" on the cover. Buy it in long lengths on reels or in cartons and cut it on the job without waste. Your wholesaler also stocks liquid-tight connectors. Free Booklet S-542 gives full information on Sealtite. Write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass, Ltd., New Toronto, Ont. Sealtite is approved by Canadian Standards Association.

*Pat. Applied For 59135

CUTAWAY SECTION of Type U.A. Sealtite shows tough polyvinyl jacket over flexible metal core. Copper conductor wound spirally inside conduit gives positive ground.

Insist on the conduit marked

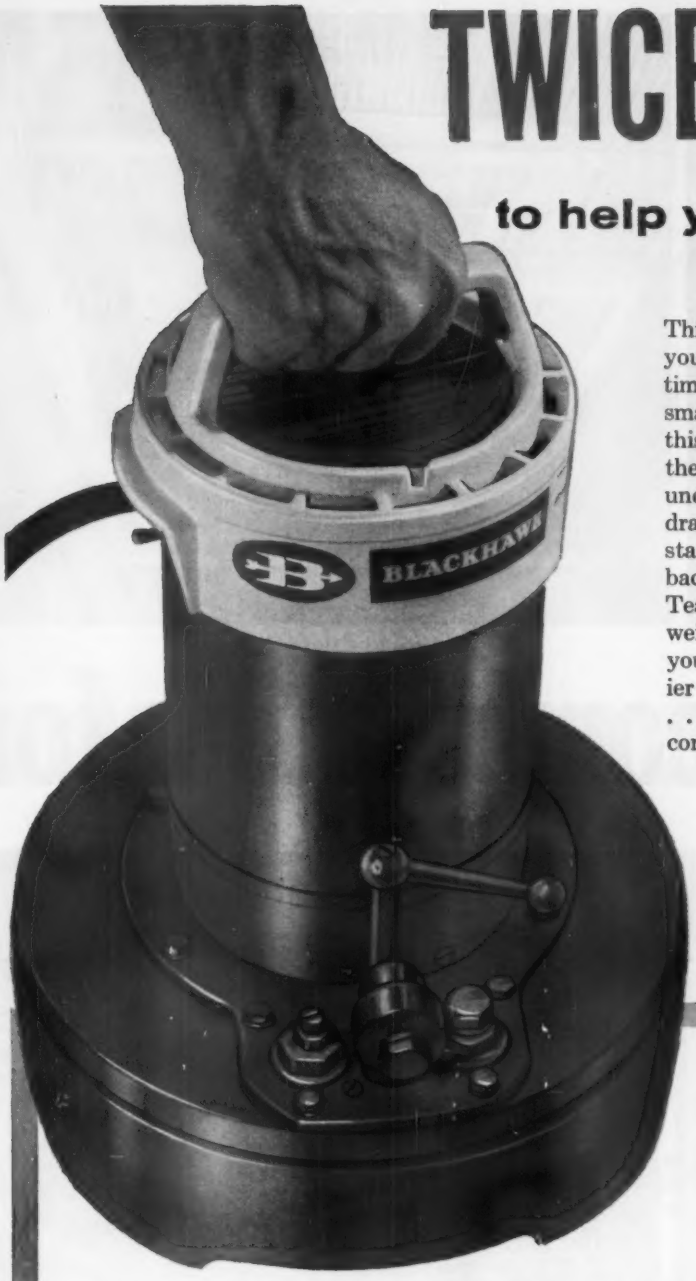
SEALTITE®

Flexible, Liquid-Tight Conduit

an **ANACONDA®** product

TWICE AS FAST

to help you slash bending time up to 50%



This new 2-speed Blackhawk workhorse gives you more usable power — faster — to save you time on every pipe bending job . . . large or small. Compare with all others . . . you'll find this new 10,000 psi power package approaches the load *twice* as fast . . . with *twice* the speed under load of any other portable, electric-hydraulic pump. And, *only* Blackhawk's P-550 starts *safely* under full load . . . no need to back off — you save time while bending! Team the P-550 with a Blackhawk featherweight one-shot bender (or any other benders you now have) and you're set for faster, easier bending . . . ready to take on more jobs . . . make bigger profits during the coming construction rush!

NEW! P-550 2-speed portable, electric-hydraulic pump. Suggested user price, only $370

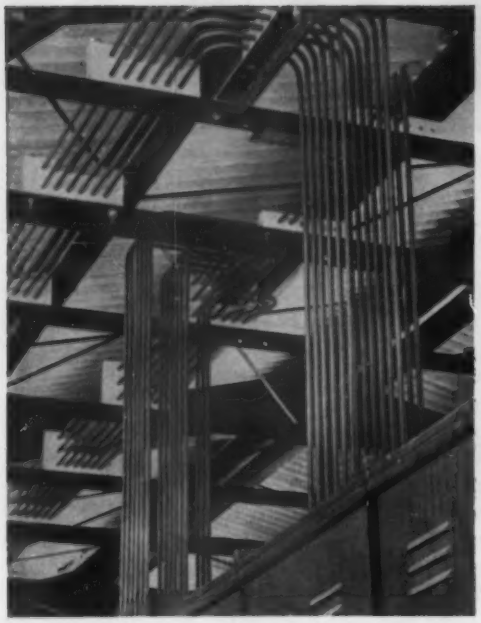
Ask for a TRY-BEFORE-YOU-BUY Demonstrator Kit!

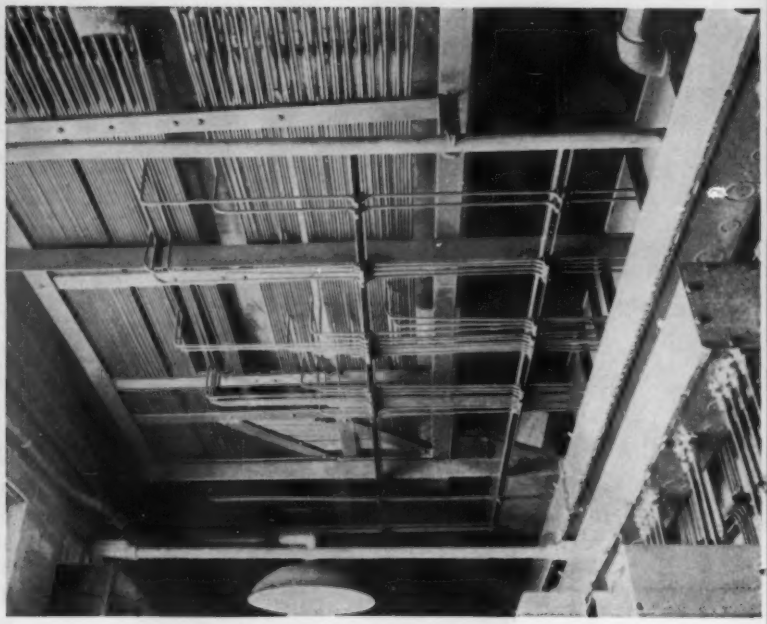
Here's your chance to compare and try *before* you buy. See your Blackhawk distributor for a one-shot aluminum bender and a P-550 pump demonstration kit that you can use *on your job!* Prove to yourself how much *more* time you save . . . how much *more* profit you can make on every job. And, you can *pay as you profit!* Many distributors are offering *interest-free* extended terms . . . up to six months to pay! Try a demonstrator and modernize your equipment now.

"World's Largest Manufacturer of Hydraulic Tools"

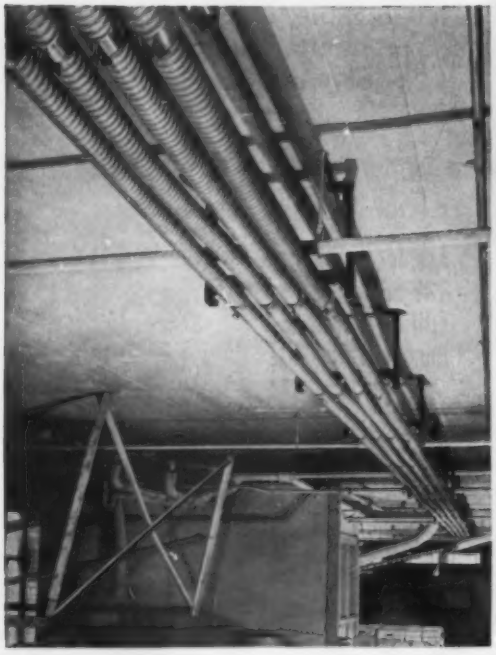
BLACKHAWK

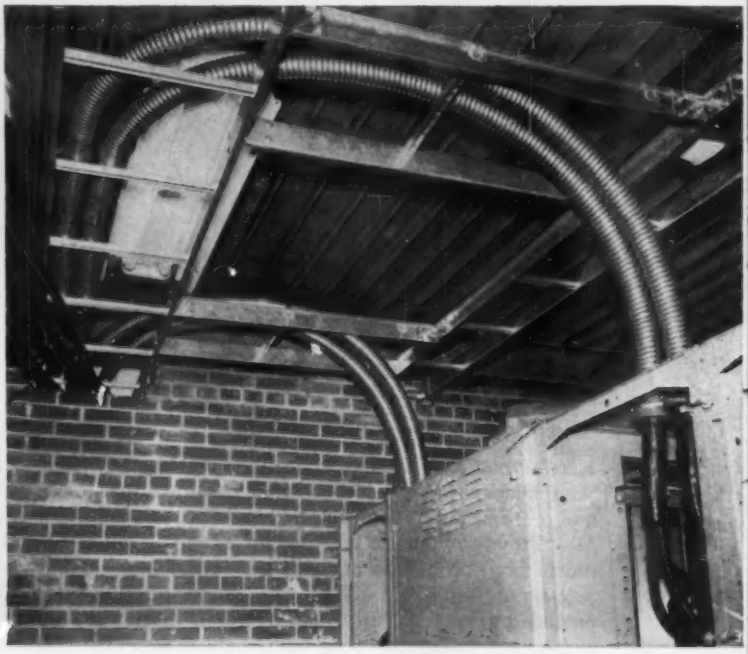
BLACKHAWK MFG. CO., Dept. H-2059, Milwaukee 46, Wis.



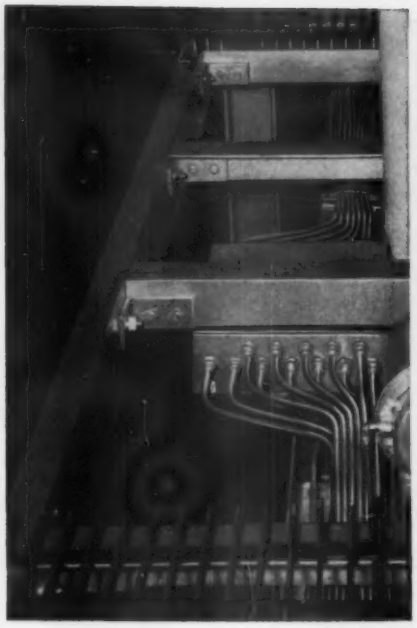


the right combination for





ONLY GENERAL CABLE MANUFACTURES BOTH TYPE MI AND INTERLOCKING ARMORED CABLES. CONTACT YOUR NEAREST GENERAL CABLE SALES OFFICE FOR FULL INFORMATION AND SPECIFICATIONS.



type mi cable

for power distribution, control and lighting circuits

TYPE MI CABLE has solid copper conductors and sheath separated by highly compressed inorganic insulation! Just about indestructible, yet it trains easily over and around obstructions. Naturally it needs no protection: just train it and terminate it. MI is compatible with all other wiring systems. It is completely resistant to moisture, age, nearly all chemicals, temperatures up to 185°F with standard terminations, 482°F with special terminations; and it is approved for use in hazardous areas. It will last forever.

industrial power

Type MI Cable and Interlocking Armored Cable work together to lower installation costs, minimize space requirements, provide maximum flexibility and accessibility in your cable systems.

inter-locking armored cable

for feeder circuits

GENERAL CABLE'S Interlocking Armored Cable combines flexibility with the mechanical protection normally afforded by metallic conduit, yet has the same current rating as cable in free air. It can be trained to fit the contours of buildings and surrounding equipment and provides a neat, compact installation. It is available in bronze, aluminum and steel and may be applied over most cable insulations in the voltage ranges recommended by industry standards. Protective coverings are available to combat environmental conditions which might cause pitting or corrosion of the interlocking armor.

GENERAL CABLE CORPORATION
65 Offices and Distributing Centers Coast-to-Coast

420 Lexington Avenue,
New York 17, N.Y.

for quality and service specify... **GENERAL CABLE**

DODGE REPORTS help you flush out live opportunities

Successful contractors know that information and timing are vital to getting business in the competitive new building market. That's why the smart contractor uses *Dodge Reports* — to select the jobs he wants to go after . . . jobs he knows will be profitable . . . and to find out exactly when and where to *act*.

Dodge Reports are mailed to you daily. They tell who's going to build what and where — in your area . . . in the types of construction you're interested in.

You know at a glance whether any given project is right for *you*. You know when bids (and re-bids) are wanted — and you know with whom you're competing. You never miss an opportunity for lack of the facts.

If you do business anywhere within the 37 eastern states, you should learn how *Dodge Reports* can improve your operation and your profit picture . . . keep you ahead of competition. Get complete information on *Dodge Reports* . . .

WRITE FOR FREE BOOK

F. W. Dodge Corporation, Construction News Division,
119 West 40th Street, New York 18, N. Y., Dept. ECM59

Send me the book "Dodge Reports — How to Use Them Effectively" and let me see some typical Dodge Reports for my area. I am interested in the general markets checked below.

☐ House Construction ☐ General Building
☐ Engineering Projects (Heavy Construction)

Area _____

Name _____

Company _____

Address _____

City _____ Zone _____ State _____

Painting by Ned Seidler

FACT

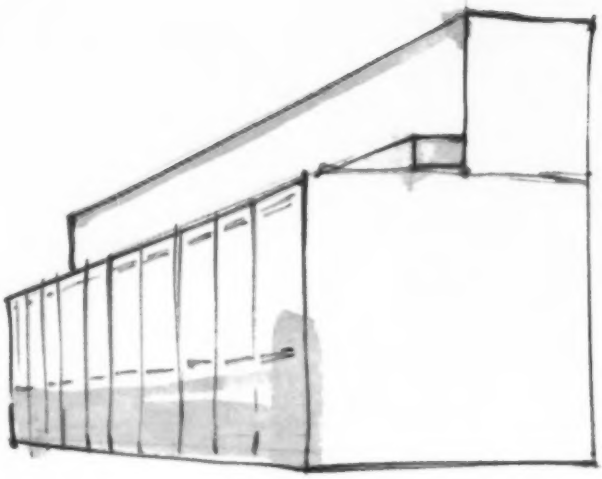
A dollar allocated for electrical equipment is worth more . . . when it is used to buy I-T-E equipment. Because I-T-E's policy is to build its equipment better, and yet charge no more.

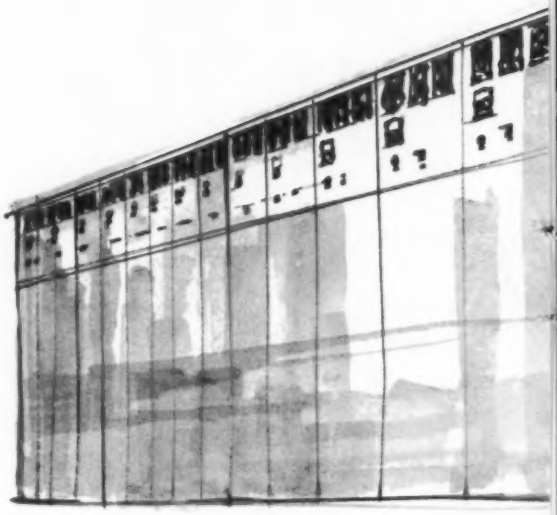
Take a typical secondary unit substation, for example. It features the new K-LINE circuit breakers . . . today's most advanced line. They stack four high in ratings up to 600 amp . . . save roughly ⅓ the space and half the weight formerly required. Circuit breaker pulldown handle with stored energy mechanism gives quick-make closure that means greater operator safety and longer contact life. The breaker can be drawn out to disconnect position without opening the door. And if the load increases later, expanded range trip devices adjust quickly and without added expense.

These features add up to real dollars and cents savings over the life of the equipment. Yet they cost nothing extra. In addition, I-T-E substations are engineered and manufactured in a single I-T-E plant for extra installation ease and better performance.

There are other I-T-E facts too. Turn page.

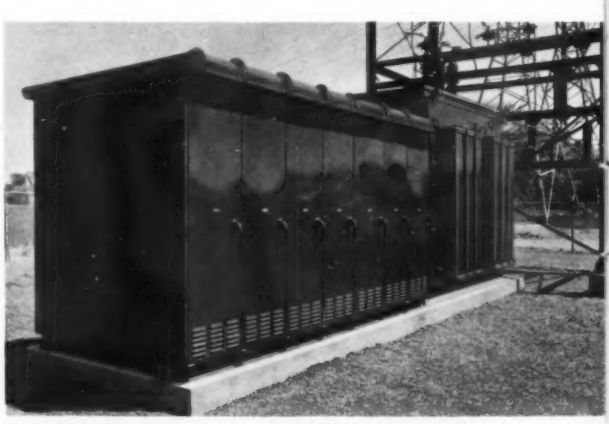
I-T-E CIRCUIT BREAKER COMPANY





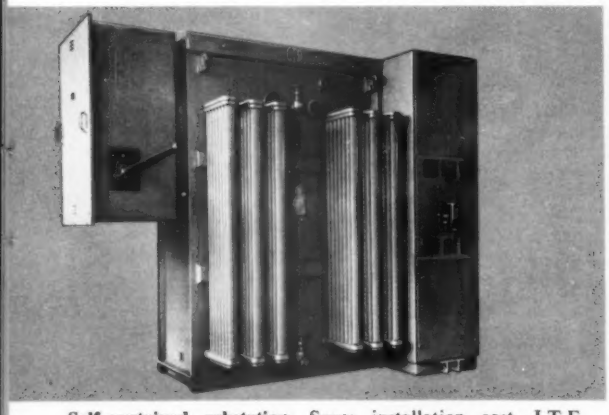
WHERE ELECTRICITY GOES I-T-E GOES

Are you fully acquainted with the broad I-T-E line . . . and the many ways it can help your dollars buy more?

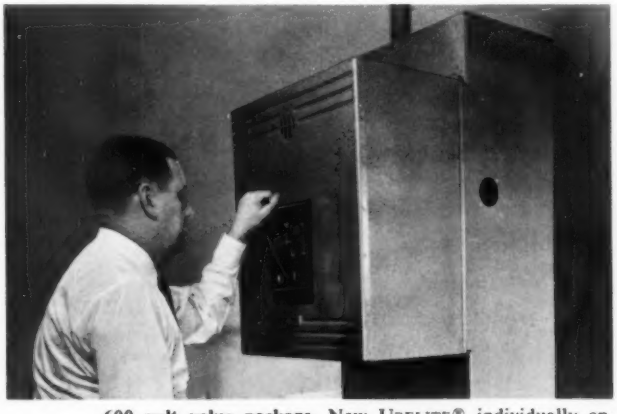


Custom designed at no extra cost. I-T-E primary unit substations are designed and built to meet the specified power, space and future expansion requirements of the particular installation for which they're ordered. In addition to standard outdoor metal-clad construction, weatherproof walk-in switchgear is also available. Transformer and switchgear sections are constructed in the same plant to assure smooth coordination of components, easier assembly, pretested performance, and on-time delivery.

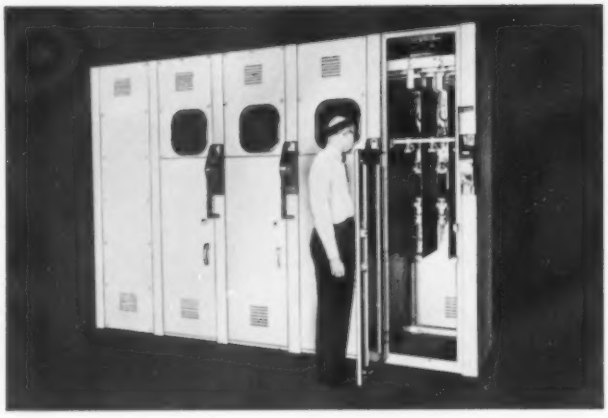
Protection for primary power. I-T-E metal-clad switchgear has many extra advantages not available elsewhere. Take a good close look. You'll find extra sturdiness that means extra serviceability. And extra craftsmanship that gives the owner a feeling of pride. For easy inspection, even the rear doors are hinged, and components are completely accessible. All essential circuit breaker components are mounted on the breaker for easier access. Uniform flux density magnetic arc field means superior protection . . . especially against high current faults. For extra safety, breakers stop automatically in test position when they're rolled into the compartments. They can't be moved into or out of connected position unless they're open.



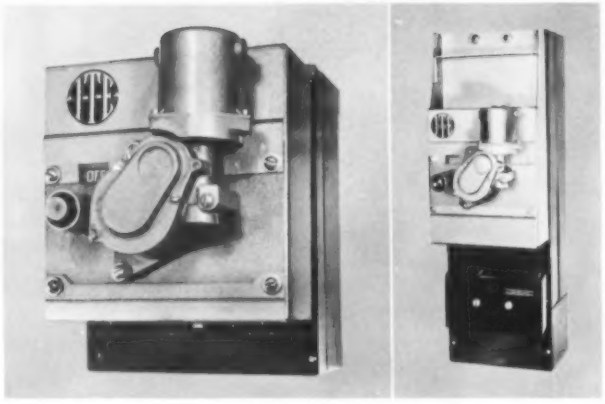
Self-contained substation. Saves installation cost. I-T-E TRANFO-UNIT combines primary disconnect, transformer and secondary circuit breakers all in one package. Nothing else to buy. Simplifies ordering. Delivered complete. Installation time and cost reduced to an absolute minimum. No complicated assembly of separate parts. Gives neat appearance. Completely safe. No live components open to contact by personnel. Needs no fence. Use for incoming power up to 3000 kva. Or spot near load areas in large plants.



600 volt value package. New URELITE® individually enclosed I-T-E K-LINE circuit breaker is ideal for single circuit protection and control, such as large motors and other heavy loads or for service entrance on many commercial-type buildings. Main disconnect contacts are visible through a side window for extra safety. Features quick-make closure, closed door disconnect, and expanded range trip device. Available in capacities from 15 to 1600 amp continuous, up to 75,000 amp interrupting.



Economical primary switching. I-T-E power switching centers save cost and time. Give dependable fused protection at low initial investment. Building block design speeds delivery. Preassembled units easy to install. Performance-proved I-T-E switches close safely into fault. Available for remote or automatic control. Up to 14.4 kv and 1200 amp.



Molded case economy . . . remote control luxury. Now I-T-E CORDON® circuit breakers are available with new TELEMAND* motor-operators for remote opening, closing or resetting. Gives pushbutton control from a distance. Permits automatic operation. CORDON circuit breakers provide up to 100,000 amp interrupting capacity in roughly half the switchboard space required by alternative devices. They cost approximately ⅓ less. TELEMAND is available for the complete range of molded case circuit breakers from 70 to 800 amp.

**Telemand is an I-T-E trademark*

I-T-E Circuit Breaker Company C-63A

1900 Hamilton St., Philadelphia 30, Pa.

- ☐ Secondary unit substations
- ☐ Metal-clad switchgear (4.16 and 13.8 kv)
- ☐ Primary unit substations
- ☐ URELITE circuit breakers
- ☐ Molded case circuit breakers
- ☐ Metal-enclosed bus
- ☐ Outdoor air switches
- ☐ TRANFO-UNITS
- ☐ Power switching centers
- ☐ TELEMAND (motor-operated molded circuit breakers)
- ☐ K-LINE LV switchgear (600 volt)
- ☐ Reclosers
- ☐ Distribution cutouts
- ☐ Other.....

Name.....Title.....

Company.....

Street.....

City.....Zone.....State.....

SEND COUPON

Get complete, up-to-date information on I-T-E equipment.

I-T-E CIRCUIT BREAKER COMPANY

...installation easy at

110 WILLIAM STREET BUILDING with

REPUBLIC

RIGID STEEL

CONDUIT

110 William Street Building, New York, New York
Architect: Sylvan Biene, New York, New York
General Contractor: Irons & Reynolds
Electrical Contractor: Zweifel-Davis Company

Republic Rigid Steel Conduit was used throughout the construction of the beautiful 32-story 110 William Street Building. Notice smooth, wrinkle-free bends and unbroken galvanized surface.

Bending was easy. Installation was easy. Because, Republic Rigid Steel Conduit offers highest degree of uniformity and ductility.

Threads are clean, sharp, free-running. Welds are sound, smooth, strong. Surface is fully protected by a galvanized coating which will not peel, flake, or chip off under normal bending.

High quality Republic Rigid Steel Conduit is made of soft ductile steel, produced by the continuous weld process. This process heats the steel to exact temperatures and immediately forms, welds, sizes it into a perfect tube. And Republic Rigid Steel Conduit meets rigid electrical codes and carries the UL Label of inspection.

To learn more about Republic Rigid Steel Conduit, call your Republic representative. Or, write direct.

REPUBLIC STEEL
STEEL AND TUBES DIVISION

REPUBLIC STEEL

Cleveland 8, Ohio

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION
DEPT. C-7764
212 EAST 131st STREET, CLEVELAND 8, OHIO

I want to know more about Republic Rigid Steel Conduit. Please send additional information.

Name _____ Title _____

Firm _____

Address _____

City _____ Zone ____ State _____

INSTALLATION: Lowell Five Cent Savings Bank
North Chelmsford Branch
North Chelmsford, Massachusetts

ARCHITECT: Arthur Englund, Lowell, Massachusetts

ELECTRICAL CONTRACTOR: J. M. Richards Company
Lowell, Massachusetts

DISTRIBUTOR: Frank P. McCartin Company
Lowell, Massachusetts

FIXTURES: Litecontrol #1548-RS and #1524-RS troffers with Holophane #6010 CONTROLENS*

FIXTURE SPACING: 8'-0" on centers

CEILING HEIGHT: 9'-5"

INTENSITY: Average 55 Footcandles in Service

Bank Interest Item:

New, Lower Brightness Lighting

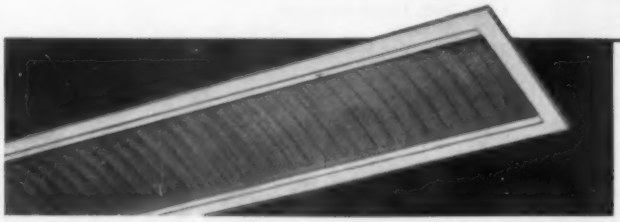
– by LITECONTROL

Very efficient lighting at sensible first cost (and upkeep) is being "deposited" at this branch bank. The desirable low brightness was achieved by LITECONTROL troffers which use the new Holophane 6010 concave acrylic plastic lens to excellent advantage. You couldn't ask for more comfortable lighting. Four feet long, the lens is lightweight . . . easy to handle . . . shatterproof.

The fixture has a removable hinged door, which may be installed to open from either side. A trigger catch permits simplified access. Maintenance and cleaning are easy indeed.

Many branch banks (main ones too), stores, offices, hospitals, libraries can use lighting like this. It's eminently practical. And inexpensive, too. Think of LITECONTROL for your next job.

*Reg. Holophane Company, Inc.



LITECONTROL
Fixtures
KEEP UPKEEP DOWN
LITECONTROL CORPORATION,
36 Pleasant Street, Watertown 72, Massachusetts

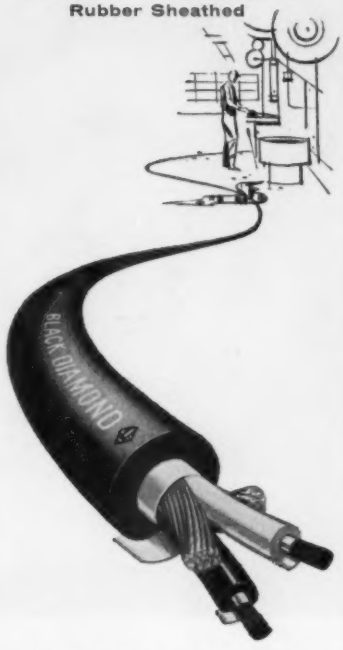
DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

Diamond has all 3 portable cords

Red-D-Prene®
Neoprene Sheathed

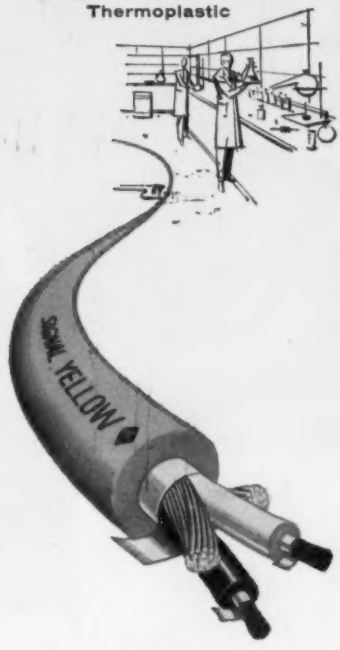
for hot, oily locations

Black Diamond
Rubber Sheathed



for general purpose use

Signal Yellow
Thermoplastic



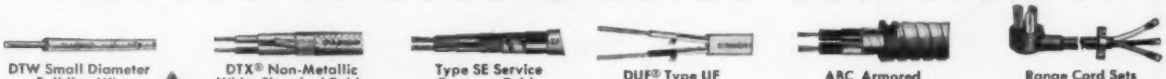
for all locations where heat is no problem

Red-D-Prene for mill and plant use is designed with tough, oil, heat and flame resistant Type MD (Mill Duty) neoprene jacket in industrial red for ready identification.

Black Diamond has durable rubber jacket protecting against alkalies, acids and moisture. Very flexible construction prevents kinking in service.

Signal Yellow has a jacket of yellow thermoplastic that is quickly seen . . . clean to handle . . . smooth sheath will not readily collect dirt. Easy to pull.

DIAMOND IS ALSO A PRIME SUPPLIER OF

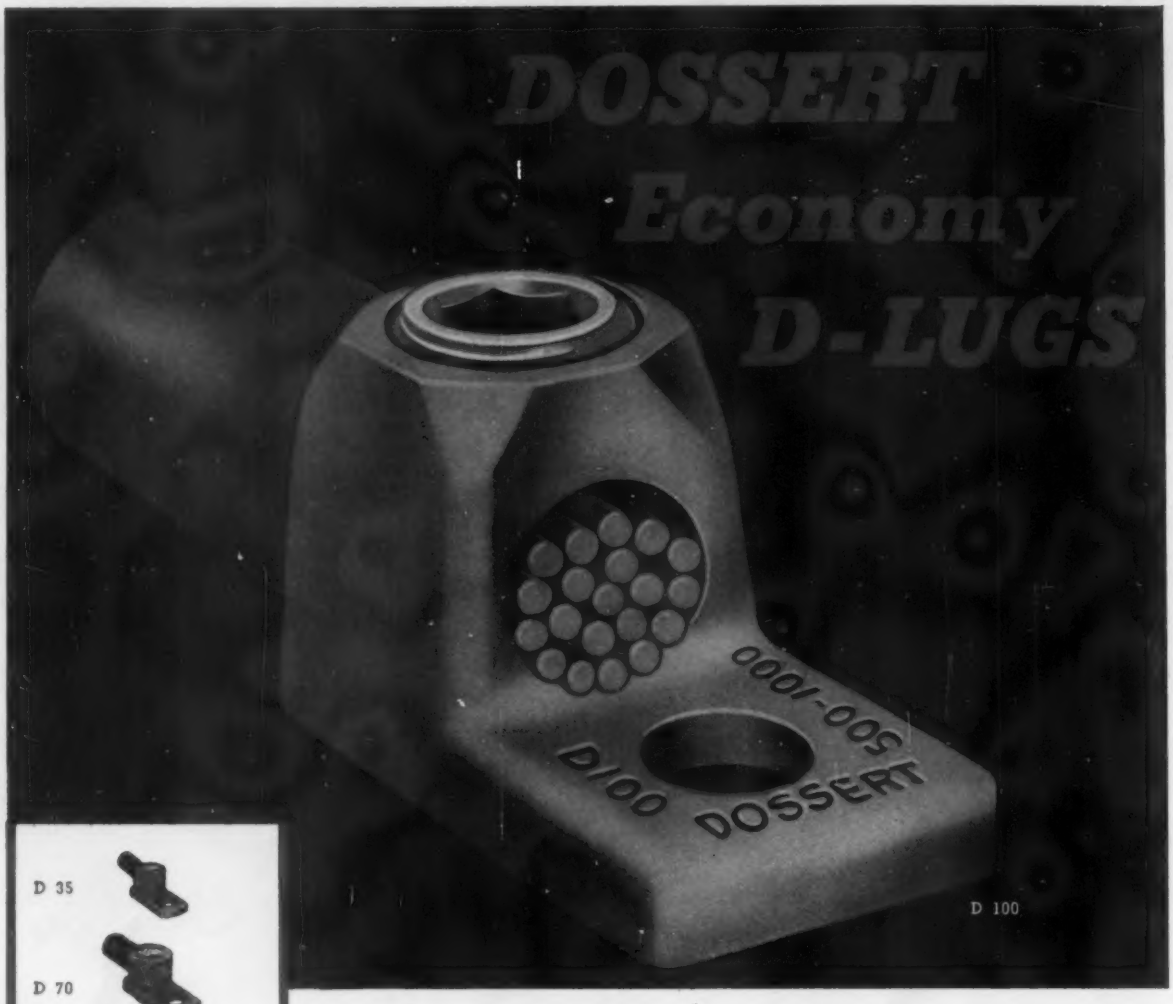


DTW Small Diameter Building Wire | DTX® Non-Metallic White Sheathed Cable | Type SE Service Entrance Cable (Armored & unarmored) | DUF® Type UF | ABC Armored Bushed Cable | Range Cord Sets

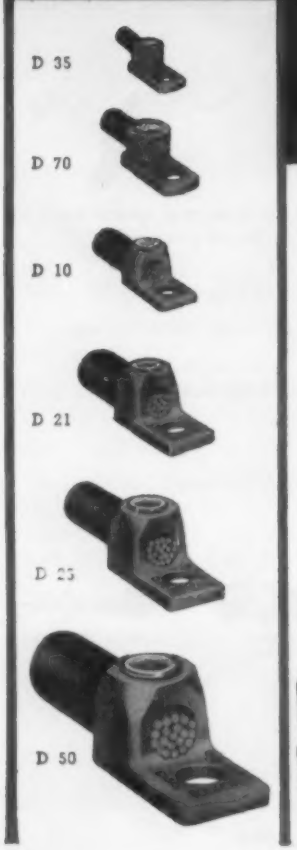
Trade Mark ®

DIAMOND
WIRE and **CABLE** Company
Sycamore, Illinois
WAREHOUSE: BIRMINGHAM, ALABAMA

DOSSERT Economy D-LUGS



D 100



Here is a complete and low-priced line of D-LUGS. These connectors are more compact and heavier in weight to insure cooler operation under more severe loads, while being much easier to install. Only seven sizes accommodate from 14 SOL. to 1,000,000 CM.

FEATURES:

- **Rugged construction**
- **Made of high conductivity copper alloy**
- **Suitable for all purposes**
- **Variable, each connector takes wide range**
- **Exceptionally compact**
- **Reusable**

Write for detailed information and prices!

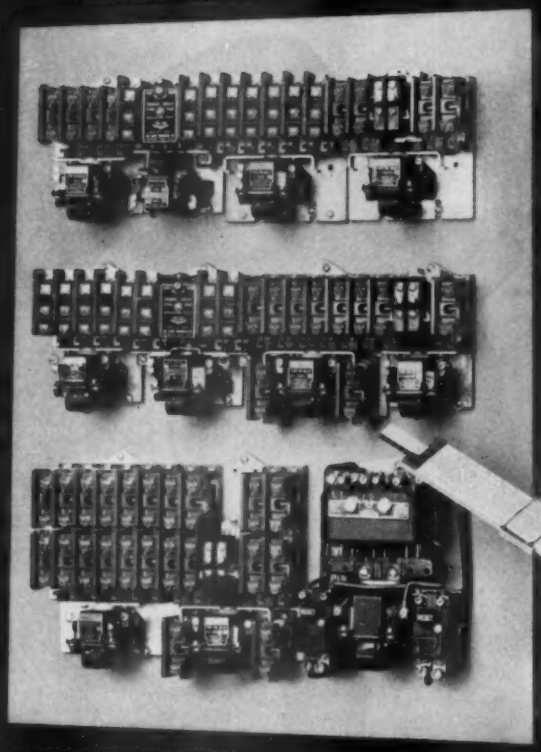
50 YEARS OF TECHNICAL KNOW-HOW

DOSSERT MFG. CORP.

249 Huron Street, Brooklyn 22, N. Y. Representatives in all principal cities

IN CANADA: W. S. Gerrie & Assoc., Ltd., Toronto

WHY SPACE IS
FRONT-PAGE NEWS...



Compact Clark Relays control 72 circuits from panel area smaller than a newspaper

In this day of space exploration and space economy, it's news—front page news—when you can get 72 separate, controlled circuits all on a panel no larger than 15" x 20".

Clark Controller, with the most complete and integrated line of control relays available today—convertible pole, latch, universal pole, and time delay—does it! And only Clark offers such a wide range of operation, so many contacts, in a panel area of such small size.

Shown mounted here with the Clark Size 1, Type "CY" Starter are 10 compact Clark Relays which include four time delay contacts (two normally open, two normally closed), 52 instantaneous contacts (14 normally open, 14 normally closed, and 24 convertible), plus 16 latching contacts (all convertible).

The same engineering leadership and superior workmanship that made Clark Controller the *standard of quality* for controls in heavy industry, is inherent in the broad line of Clark Relays for modern panels.

The "modular construction" of all Clark "PM" Relays insures integrated uniformity, compactness and flexibility. Functional alignment in mounting results in neater, more uniform panels and most efficient utilization of valuable space. And because "PM" relays are available in a wide variety of pole combinations, providing up to 14 contacts on a single relay, you can control more circuits—save on relay requirements.

For more information on the complete line of Clark "PM" Relays which is making space-saving headlines, contact your nearest Clark Controller sales office or distributor. Or, write direct to Clark Controller for free bulletins.

The **CLARK CONTROLLER** *Company*

Everything Under Control • 1146 E. 152nd St. • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

for the easiest, best insulated

crimp splice you've ever seen...

WRAP-CAP IT!

IDEAL

"Wrap-Cap" (Patented) CRIMP CONNECTORS

with the UNIQUE DIAPER WRAP INSULATOR

Flash-proof all around the joint and *between the wires, too!*

"Wrap-Cap" Crimp Connectors give you perfect, prefabricated insulation on every joint, every time . . . *the easy way.*

Actually Triple-Safe

1. "Wrap-Cap" Insulators are virtually puncture-proof, with *extra-thick* protection over wire ends.
2. Deep skirt completely covers bare conductor — even if wires are *not* stripped evenly.
3. High-tensile cadmium-plated steel sleeve has greater gripping power—vibration-proof—pull-proof—with low electrical resistance.

ONLY 2 PARTS

the crimp sleeve and the "Wrap-Cap"

Just crimp the sleeve, apply the "Wrap-Cap" Job's done!

Listed as pressure cable connectors for general use (600 V.) in branch circuit and fixture wiring.

No Extra Tool Needed — just use IDEAL Electricians Pliers to provide a double-indented, double-strength crimp that holds for a lifetime.

If you are not now using IDEAL "Wrap-Caps", why not find out right now how much better a crimp connector can be? Get a supply today from your IDEAL Distributor—or mail the coupon for complete data.

Sold through

AMERICA'S LEADING DISTRIBUTORS

In Canada:

Irving Smith, Ltd., Montreal

IDEAL INDUSTRIES, Inc. IDEAL
1041E Park Avenue, Sycamore, Illinois

Please send catalog data on IDEAL Crimp Connectors and Electricians Pliers.

Name_____

Company_____

Address_____

City_____ Zone___ State_____

No plastic electrical tape *remembers its job like*

REG. U.S. PAT. OFF.
SCOTCH BRAND

No. 33!

No plastic electrical tape stretches like "SCOTCH" No. 33—and has the built-in "memory" to recover with just the right tension to pull up snug and tight in the splice wrapping! This means "SCOTCH" No. 33 actually *works with you* in making smooth air-and-moisture-tight splice coverings. But remember, it's not the genuine "SCOTCH" No. 33—the best general purpose tape for all uses—unless it has "Scotty's" plaid on the can and "No. 33" inside the red core. Ask your electrical distributor about the full line of "SCOTCH" Brand Splicing materials, or write us for complete information.

"SCOTCH" AND THE PLAID DESIGN ARE REGISTERED TRADEMARKS OF 3M CO., ST. PAUL 6, MINN.

The price per splice is less . . . let us prove it!

MINNESOTA MINING AND MANUFACTURING CO.,
St. Paul 6, Minn., Dept. CB-59

All right!—show *me! Send someone around to* prove *that the price per splice is less with "SCOTCH" No. 33!*

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

MINNESOTA MINING AND MANUFACTURING COMPANY
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

UTICA

fully guaranteed

USE UTICA and do the job with industry's finest quality hand tools . . . the tools preferred throughout the telephone and electrical construction fields. Pliers and wrenches drop-forged for rugged durability! Induction hardened at points of greatest wear —for extra strength! And like all Utica hand tools, they are fully guaranteed. **Utica Drop Forge & Tool Division, Kelsey-Hayes Co., Utica 4, New York.**

USE **UTICA** (U TI CA) *the tools the experts use!*

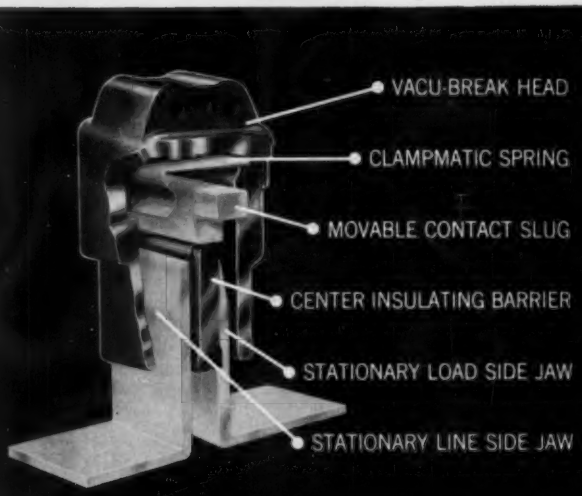
Hallmark of Quality since 1895

FOR SAFETY'S SAKE BUY VACU-BREAK

There's a big difference in safety switches—a difference between maximum safety and halfway safety—low maintenance and excessive maintenance. These differences are readily apparent when you look at the design and operation of the BullDog Vacu-Break Clampmatic* Safety Switch.

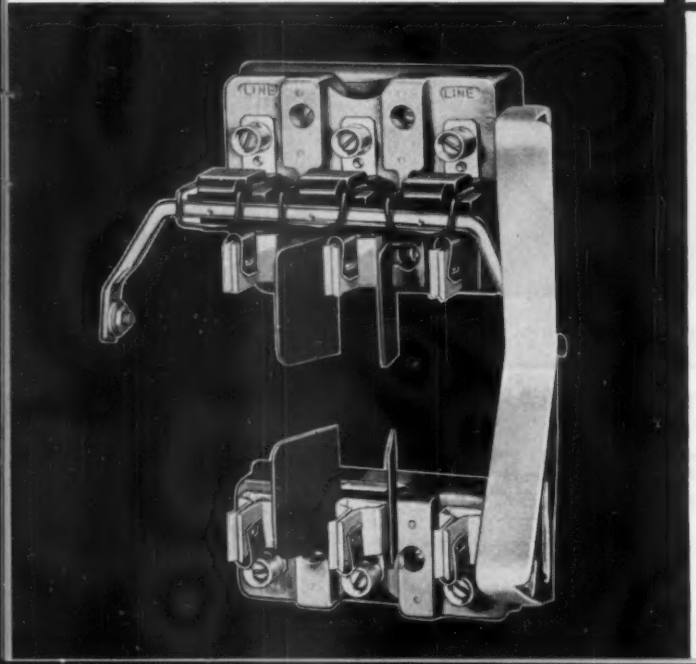
THE VACU-BREAK: Contacts are housed inside compact arc chambers which have very little air space. When contacts are "broken" under load, arcs can't build up because of the lack of oxygen. Pitting and burning of the contacts are reduced to the absolute minimum. Maintenance is virtually eliminated.

POSITIVE SWITCHING: For positive safety, the Vacu-Break switching mechanism does not rely on tricky toggles or springs to trigger the disconnect operation. The operating handle is directly connected to the contact heads by means of a sturdy *metal* rod. Push the handle "OFF" and the switch *is off!*



Vacu-Break heads are connected directly to the switch handle. No toggles or triggers . . . no tricky springs. No danger of switching failure, either. One of several exclusive BullDog Vacu-Break features that set the performance standards for the industry.

Close-up of Vacu-Break head shows movable contact slug inside the compact, oxygen-limiting arc chamber. Clampmatic spring assembly assures bolt-tight contact, speeds "break". This combination guarantees positive, safe operation, long switch life.



WITHSTAND 100,000 AMP FAULT CURRENT: Vacu-Break Clampmatic switches equipped with current-limiting type Amp-Traps** were subjected to 100,000 amp short circuit current. *The switches were undamaged.*

Play it safe! Compare, recommend, *buy* . . . BullDog Vacu-Break Clampmatic Safety Switches. They cost no more than other switches . . . yet give you the maximum in safety and performance.

**Vacu-Break and Clampmatic are registered trademarks of the BullDog Electric Products Division.*
***Amp-Trap is a registered trademark of the Chase-Shawmut Division.*

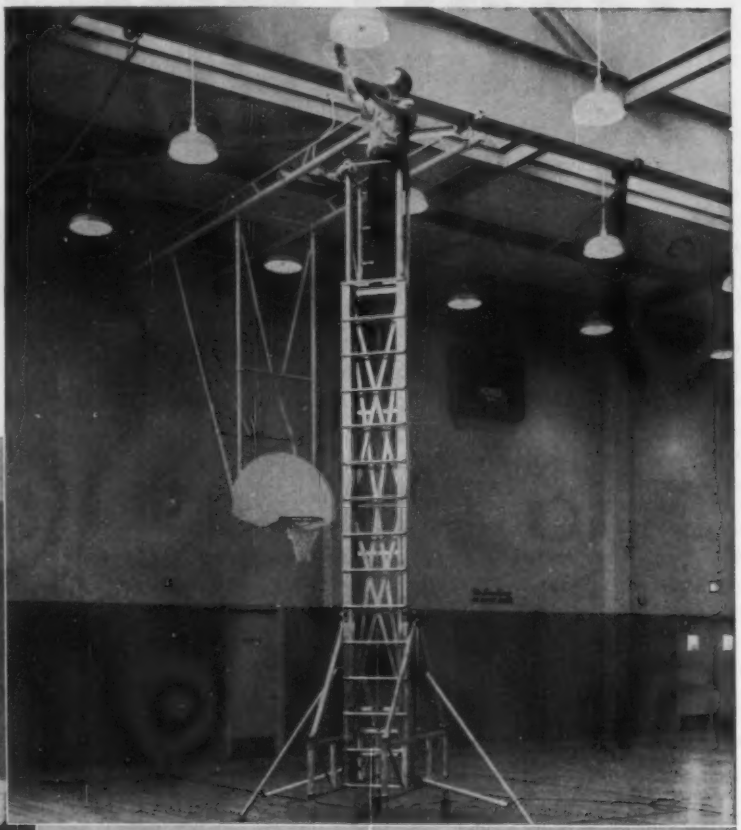
BULLDOG ELECTRIC PRODUCTS DIVISION
I-T-E CIRCUIT BREAKER COMPANY
BOX 177 • DETROIT 32, MICHIGAN

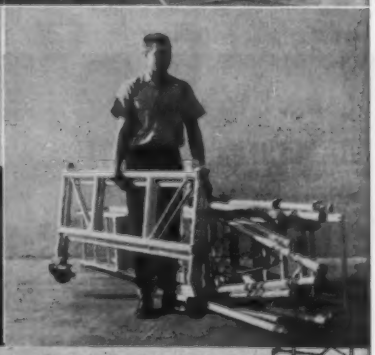
In Canada: 80 Clayson Rd., Toronto 15, Ont. Export Division: 13 East 40th St., New York 16, N.Y.

UP-RIGHT ANNOUNCES

TALLESCOPE ...telescoping aluminum work platform for overhead construction and spot maintenance

Lightweight, rapidly assembled by one man. Extends instantly for reaching heights up to 30 ft. Telescopes for rolling under trusses and other obstacles. Adjustable legs for uneven floors or stairways.





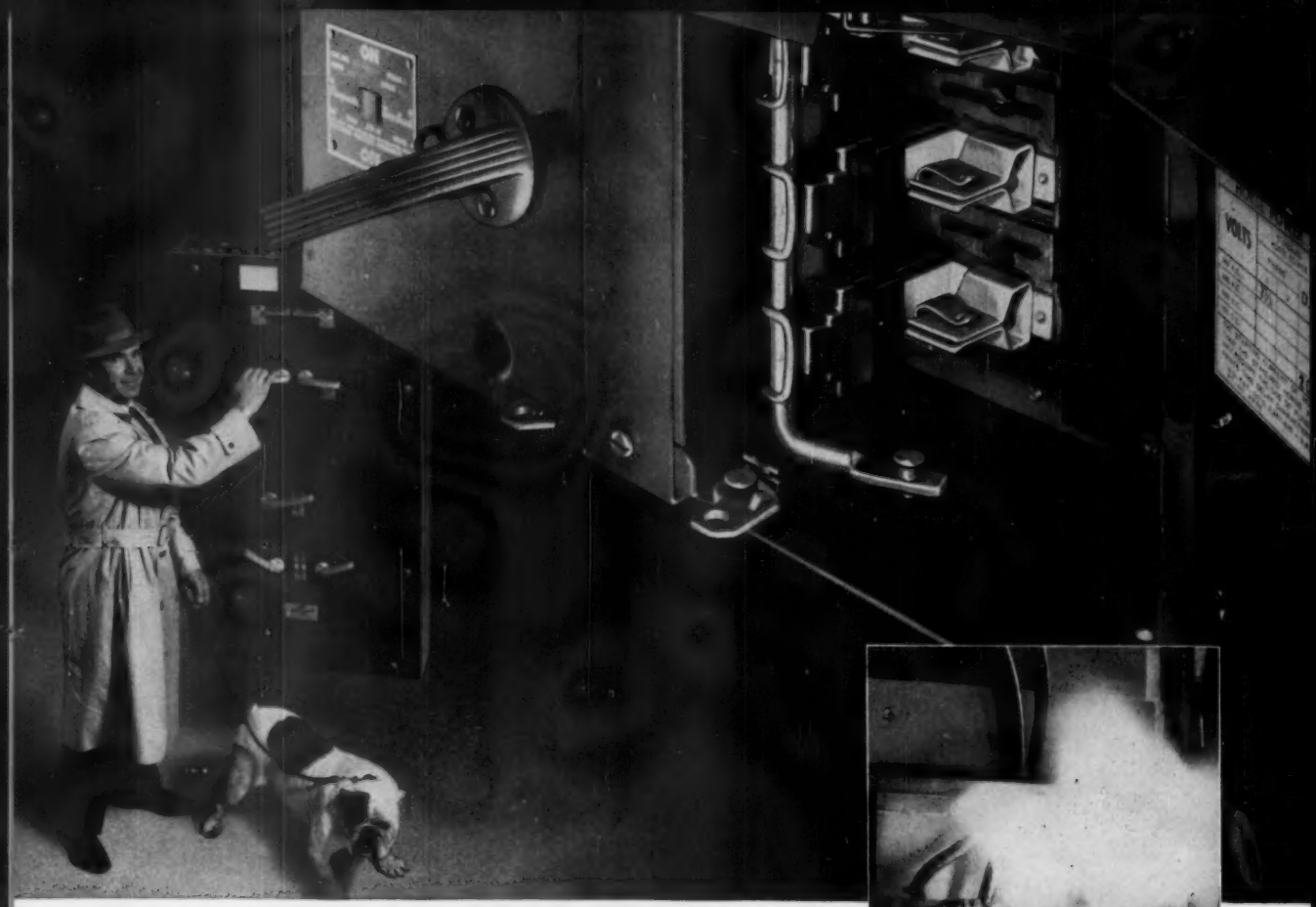
Rolls through doorways . . . only 29" wide, telescopes and folds down.

Bridges over auditorium seats.

Separates easily into 3 components for convenient storage or transportation.

FOR TALLESCOPE CIRCULAR
WRITE TO
UP-RIGHT SCAFFOLDS
DEPT. 177 • 1013 PARDEE ST., BERKELEY, CALIF.

MANUFACTURED BY
UP-RIGHT
SCAFFOLDS



Dangerous flash explosion occurs at instant of "break" in open knifeblade switch . . . causing blades to burn, pit, deteriorate. (This photograph and the one below are unretouched.)

FOR SAFETY'S SAKE, BUY VACU-BREAK POWER PANELS

Here are some basic facts why BullDog Power Panels with Vacu-Break* units are tops in safety and performance. Vacu-Break design minimizes destructive arcs because contacts are housed in compact chambers that extinguish the arcs immediately. Result: maximum safety . . . virtually no pitting or burning of contacts . . . minimum maintenance. Vacu-Break switch units are "quick-make, quick-break" with an interlocking safety mechanism. Contacts are *directly* attached to operating handle. No tricky toggles or springs. You get positive, safe switching always. And when the handle is in OFF position, you *know* the switch is *off!*

The Clampmatic* design provides clamped-pressure switching contacts to prevent overheating at these points. Needless heat-generating areas are eliminated because there are no hinged, current carrying parts . . . and all conductors are silvered. BullDog switches also withstand severe fault currents. In recent tests, standard BullDog switches with Amp-Traps** were subjected to a 100,000-amp short circuit current. *They were undamaged!*

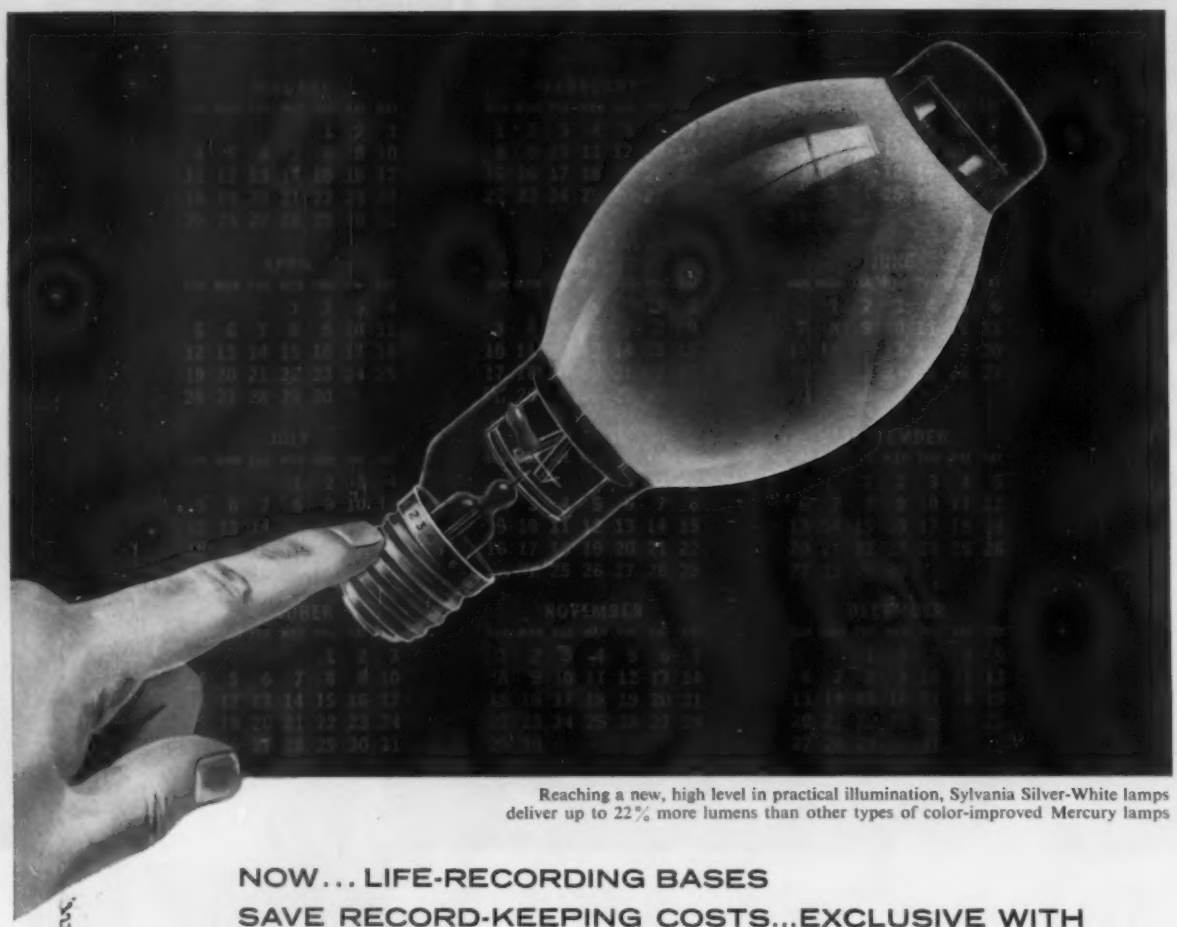
For safety's sake—and superior performance—specify BullDog Vacu-Break Power Panels.

BullDog Vacu-Break chamber smothers arcs before they can cause damage. Both are 100-amp, 600-volt switches, operating under 90-ampere, 440-volt load with 40% to 50% power factor.

BULLDOG ELECTRIC PRODUCTS DIVISION
I-T-E CIRCUIT BREAKER COMPANY
BOX 177 • DETROIT 32, MICHIGAN

In Canada: 80 Clayson Rd., Toronto 15, Ont. Export Division: 13 East 40th St., New York 16, N.Y.

*Vacu-Break and Clampmatic are registered trademarks of the BullDog Electric Products Division. **Amp-Trap is a registered trademark of the Chase-Shawmut Company.



Reaching a new, high level in practical illumination, Sylvania Silver-White lamps deliver up to 22% more lumens than other types of color-improved Mercury lamps

NOW... LIFE-RECORDING BASES SAVE RECORD-KEEPING COSTS...EXCLUSIVE WITH

Sylvania *Ruggedized* Mercury Lamps

A scratch of a simple tool, such as a screwdriver, easily records the month and year when a Sylvania "Ruggedized" Mercury Lamp is installed. This simple built-in record-keeper eliminates expensive records and time...is an instant aid in figuring installation costs accurately.

The recording base, however, is but only one reason to consider Sylvania "Ruggedized" Mercury Lamps for all of your outdoor lighting needs as well as high-bay industrial installations.

For example, Sylvania "Ruggedized" Mercury Lamps right now provide users across the country with all these important, *exclusive*, cost-reducing benefits:

Increased lumen output. Recent phosphor improvements boost the Silver-White Phosphor-Coated SH-1 lamp from 23,000 lumens in 400 watts to 25,000 lumens—the most efficient commercial mercury lamp (62.5 lumens per watt) available today.

9000 hours' average usable life. Built for long life and high lumen maintenance, these lamps have increased from 7000 to 9000 usable hours.

Ruggedized glass (PYREX brand bulbs) protects against moisture and condensation, moisture-laden or humid atmospheres, thermal shock.

Ruggedized construction throughout. Arc tube supports are specifically designed to resist and protect the lamp from destructive shocks and vibrations.

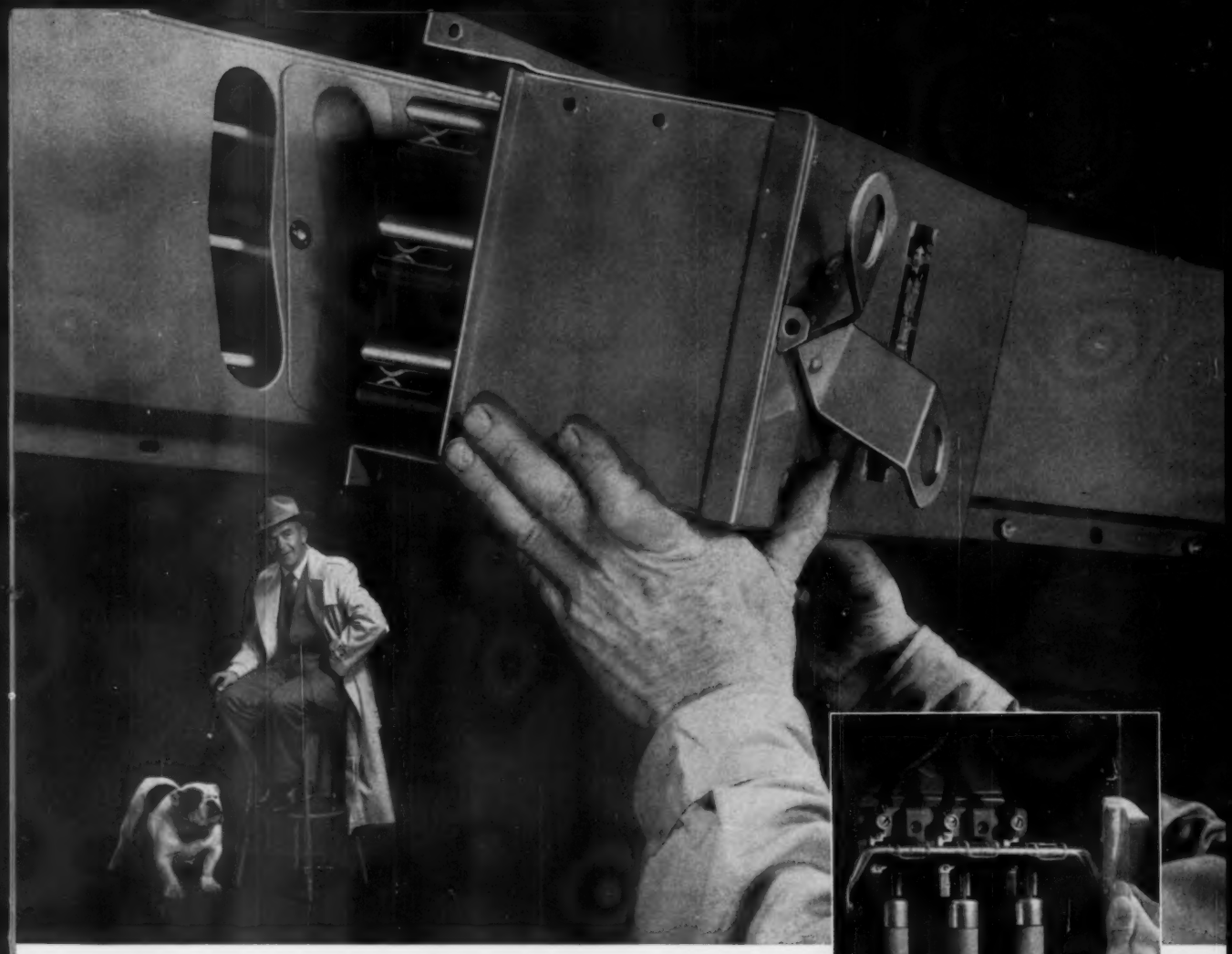
Guaranteed performance. Free exchange on any lamps which burn out during the first 1000 hours.

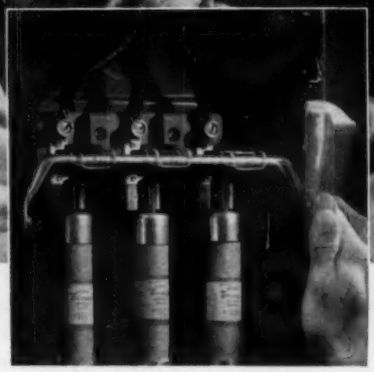
A complete line of Ruggedized Lamps covers a range of 400-, 425-, 700- and 1000-watt sizes . . . Silver-White (*Kolor-Keyed*), Clear and Color-Improved types . . . 25,000 to 62,000 lumens output.

Let Sylvania's staff of lighting engineers help evaluate your present and future lighting requirements, without obligation. For information or literature, call your Sylvania representative or write:

SYLVANIA LIGHTING PRODUCTS
Dept. 9L-8305 60 Boston St., Salem, Mass.
In Canada: Sylvania Electric (Canada) Ltd.
P. O. Box 1190, Station "O," Montreal 9

SYLVANIA
Subsidiary of
GENERAL TELEPHONE & ELECTRONICS





Vacu-Break chamber, shown above, smothers arcs at instant of break before they can pit or burn contacts. Dangerous flash explosion occurs at instant of "break" in open knifeblade unit shown below.

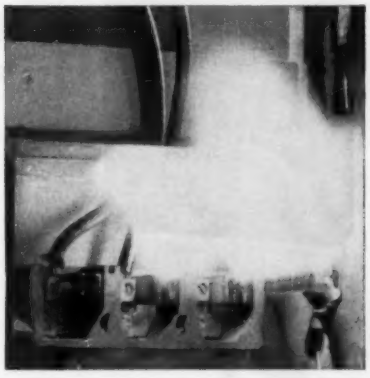
GET VACU-BREAK SAFETY IN BUS DUCT BY BULLDOG

And here's real built-in flexibility, too! Circuits plug in wherever needed with complete safety.

BullDog Plug-in Duct provides openings on 20-inch centers on either side of the duct. To tap "live" power you simply insert Vacu-Break® bus plugs. As the picture shows, reinforced fingers on all plugs insure positive pressure contact. Exclusive Vacu-Break action safeguards circuits and personnel. The enclosed arc chamber limits the oxygen supply . . . actually starves the arc before it can explode and pit or burn contacts. (The Vacu-Break bus plug has six companion plugs to meet other applications.)

Plug-in Duct is powered by Lo-X feeder duct—together they form BullDog's integrated BUStribution® system. Both ducts are available in standardized and interchangeable straight sections, elbows, tees and crosses . . . can be installed sideways, on edge, vertically or horizontally.

Protect clients against rewiring, downtime and costly production shutdowns! Specify *Bus Duct by BullDog.*



BULLDOG ELECTRIC PRODUCTS DIVISION
I-T-E CIRCUIT BREAKER COMPANY
BOX 177 • DETROIT 32, MICHIGAN

In Canada: 80 Clayson Rd., Toronto 15, Ont. Export Division: 13 East 40th St., New York 16, N.Y.

scope*

*STROMBERG CENTRAL OPERATIONS PANEL—ELECTRIC

Easily and economically installed, SCOPE conserves power, fuel and water, actually lengthens the life of associated operational equipment by tailoring "on" time to fit specific program requirements.

Now... from a recognized leader in the field of intricate timing devices and time control systems comes SCOPE (Stromberg Central Operations Panel—Electric).

SCOPE controls remote equipment *without* special or additional system wiring.

On a pre-determined schedule, SCOPE automatically controls the "on" and "off" operation of equipment in schools, offices, industrial plants, department stores and public buildings of all kinds. Thanks to such components as Stromberg's renowned Master Clock, Program Instruments and Electronic Transmitter, SCOPE can control up to 60 electronic circuits.

With the addition of auxiliary panels, it can control up to 160 circuits on one electronic frequency.

Operating with *four* frequencies, a single SCOPE panel will control 640 circuits.

In any standard installation, SCOPE will "mastermind" the programmed operations of heating and air conditioning, lighting, clocks, audible signals, attendance recorders, time stamps, locks, pumps, valves and motors.

A complete catalog—TIME AND SIGNAL EQUIPMENT—prepared especially for Architects and Engineers—is yours for the asking.

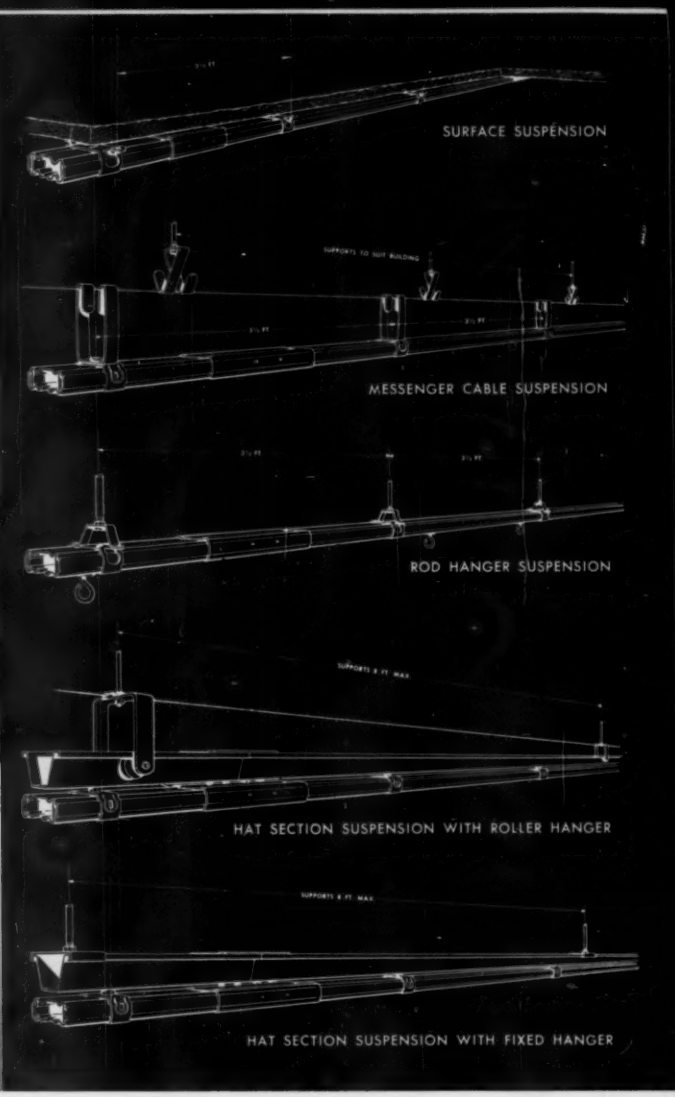
Stromberg TIME CORPORATION

MAIN STREET, THOMASTON, CONNECTICUT

GT GENERAL TIME

SUBSIDIARY OF GENERAL TIME CORPORATION

Sales & Service Offices throughout the U. S. A.


SURFACE SUSPENSION
MESSENGER CABLE SUSPENSION
ROD HANGER SUSPENSION
HAT SECTION SUSPENSION WITH ROLLER HANGER
HAT SECTION SUSPENSION WITH FIXED HANGER

TAKE YOUR CHOICE...
UNIVERSAL LIGHTING DUCT OFFERS 5 METHODS OF SUSPENSION!

You can solve virtually any lighting fixture placement problem with Bull-Dog Universal Lighting Duct. The prefabricated, standardized duct is amazingly easy to assemble and you have your choice of *five different suspension methods* for either the 20-amp or 50-amp ratings. One or a combination of these methods will adapt to any structure . . . and meet any installation requirement quickly and economically.

"ULD" is a continuous electrical outlet, with conductors running the entire length of the duct. Duct sections telescope together mechanically and electrically by a plain coupling. Light fixtures connect quickly by means of twist-out plugs which can be added or repositioned at any point. Plugs are available for direct fixture attachment or will take a standard attachment cap. The duct both feeds and supports fixtures . . . can be easily disassembled and relocated as lighting needs change.

You'll find Universal Lighting Duct is less costly than installed pipe and wire. And if the lighting plan is altered during construction, "ULD" can be repositioned without time-wasting "rewiring."

On your next wiring job look into the economies of Universal Lighting Duct. You'll find it is the most efficient, economical and flexible lighting duct system available. "ULD" is U/L listed.

BULLDOG ELECTRIC PRODUCTS DIVISION
I-T-E CIRCUIT BREAKER COMPANY
BOX 177 • DETROIT 32, MICHIGAN

In Canada: 80 Clayson Rd., Toronto 15, Ont. Export Division: 13 East 40th St., New York 16, N.Y.

Why Kaiser neoprene-jacketed cable was used in Lincoln Tunnel signal system

The Lincoln Tunnel requires a myriad of signal lights to regulate traffic under all conditions. For this complex system of circuits the designers specified multi-conductor cable manufactured by the Bristol Works of Kaiser Aluminum and Chemical Corporation. The cable is jacketed with Du Pont neoprene.

The time-proven performance of neoprene led to its use in this installation. The designers wanted a flexible, easily installed cable with an abrasion-resisting jacket to protect the conductors against rough handling. And they wanted a jacket that would give long-term protection against deterioration by exhaust fumes. They got what they wanted with neoprene.

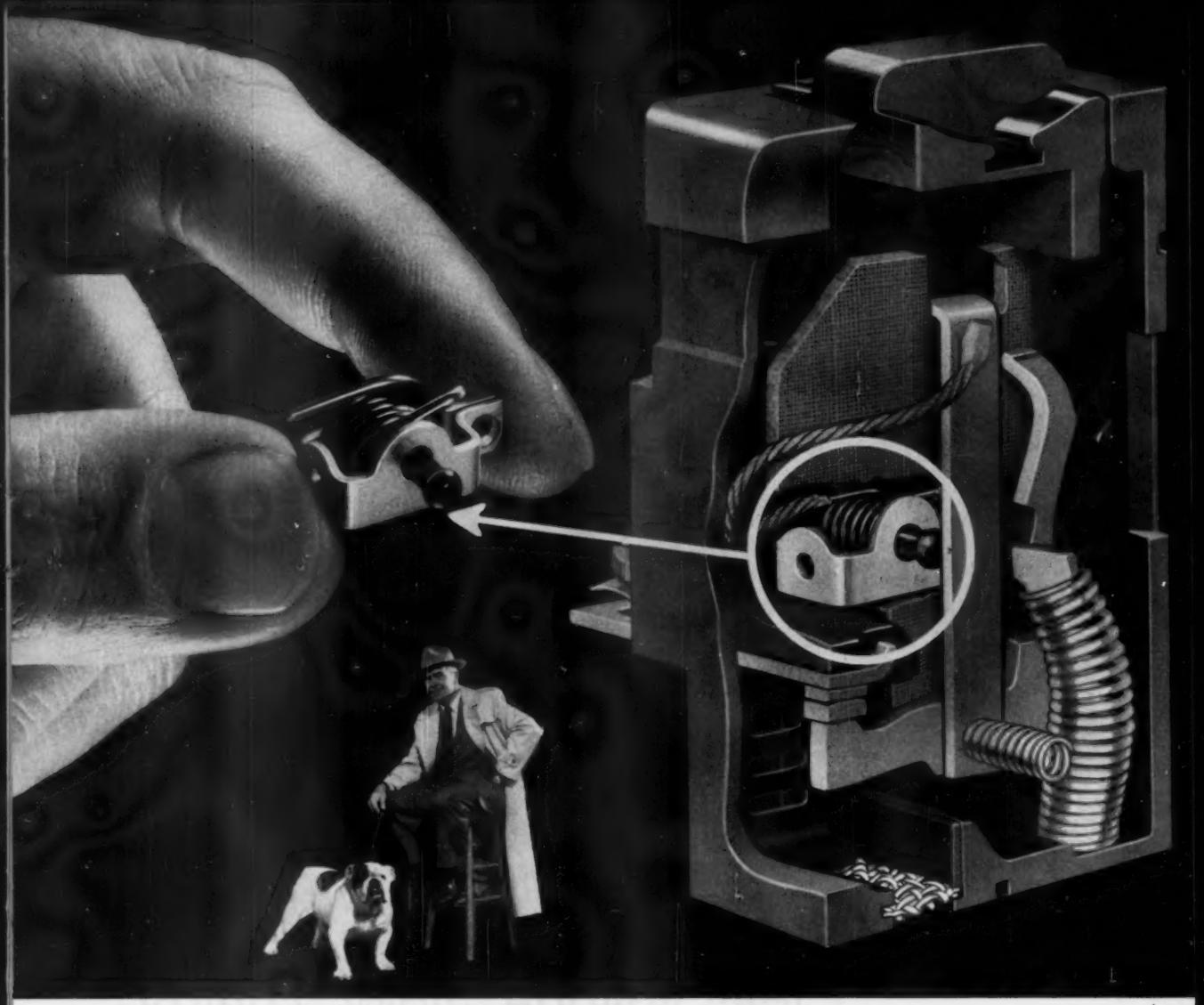
The results of countless installations prove you can be sure of lasting performance when you specify neoprene jacketing for wire and cable. For details, write to: E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. EC-5, Wilmington 98, Delaware.

DU PONT
REG. U. S. PAT. OFF.

SYNTHETIC RUBBER

NEOPRENE
HYPALON®
VITON™
ADIPRENE®

Better Things for Better Living . . . *through Chemistry*



NO TROUBLE CALLS WITH PUSHMATIC

coil protection is standard in every breaker

Protect branch circuits against high overloads and "flash-shorts" with Pushmatic® magnetic coil action! BullDog, the first to offer this protection in 15-amp and 20-amp ratings seven years ago, builds this safeguard *into every Pushmatic breaker*. The solenoid (coil) —coupled with the thermal element— provides *double* circuit safety. Makes trouble calls a thing of the past.

As you can see in the above picture the Pushmatic uses a *multi-turn coil.* High overloads or "flash-shorts" instantly set up a magnetic field in the coil—causing the metal plunger to trip the latch and break the circuit. BullDog Pushmatics provide not only maximum branch circuit protection, but protect lamp and appliance cords, too!

Small overloads are taken care of by the thermal-bimetal latch. An overloaded circuit heats the bimetal causing the latch to curve and release. A built-in time delay prevents nuisance tripping in case of harmless overloads.

Play it safe. Protect branch circuits with Pushmatic coil action! Each and every Pushmatic is rigidly tested to assure precision operation. You'll find Pushmatic double protection pays off! Multi-turn coils are standard in all Pushmatics— 15 amperes through 50 amperes.

BULLDOG ELECTRIC PRODUCTS DIVISION
I-T-E CIRCUIT BREAKER COMPANY
BOX 177 • DETROIT 32, MICHIGAN

® In Canada: 80 Clayson Rd., Toronto 15, Ont. Export Division: 13 East 40th St., New York 16, N.Y.

Unsurpassed Mechanical and Electrical Life

NEW complete line of low voltage motor control

Attractive enclosures of this new line of Size 0 through 4 Allis-Chalmers control *forecast* quality . . . modern engineering design *assures* it . . . performance tests *confirm* it. Millions of "life-test" operations attest to the functional quality in every detail — assure the ultimate in dependable performance and sure protection for personnel, motors and machines.

Contact block of glass-filled thermal-setting molding. Contacts of cadmium silver oxide, contact carrier of metal-reinforced molding, dual-voltage coils encapsulated in epoxy-resin — these are just a few of the superior materials used to assure maximum operating dependability and long life.

Accessibility — Modern design provides wide-open accessibility for fast and easy installation, modification, inspection and maintenance.

Flexibility — Flexible design permits making many modifications in the field with ease. Minimum parts requirements facilitate delivery from local stock.

A complete line of low voltage control (Size 0 through 8) and high voltage control *in all NEMA enclosures,* plus engineered control systems. Your A-C distributor or representative will give you all the details. *Or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.*

ALLIS-CHALMERS

A-5986

virden announces a new concept in home lighting

the light idea

to increase your sale of home lighting fixtures

Now you can sell lighting . . . not just fixtures! Match your customers' mode of living with the *right lighting* for every occasion . . . and gain more sales . . . more profits.

"the light idea" by Virden makes it possible. It matches lighting to today's living patterns . . . *creates the right lighting mood* for every occasion . . . from overall illumination through accent and protective lighting.

Our new 52-page, full color catalog explains "the light idea" in detail, shows and tells how to achieve it. In addition, it shows the complete new Virden line . . . new pulldowns, chandeliers, bullets . . . outdoor and garden lighting . . . in every decorator style. Truly the most brilliant collection in the industry.

Ask your Virden distributor for your copy today. You'll find him listed in the Yellow Pages under "Lighting." Or write to Virden Lighting, Dept. ECM, 5209 Euclid Avenue, Cleveland 3, Ohio.

Find It Fast In The Yellow Pages

virden LIGHTING

A Division of the John C. Virden Company • Cleveland 3, Ohio • In Canada, John C. Virden, Ltd., Toronto 16, Ontario

ANOTHER ADVENTURE IN LOW-VOLTAGE WIRING WITH

REMMIE REMCON

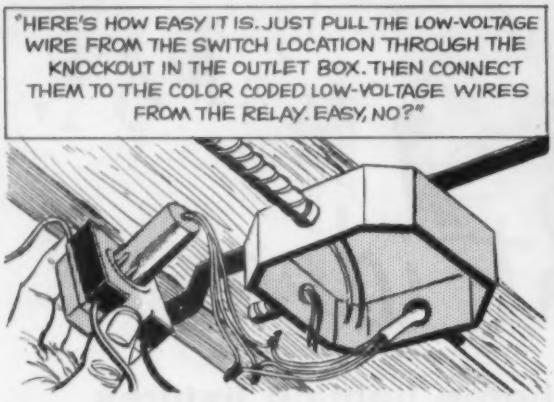
and

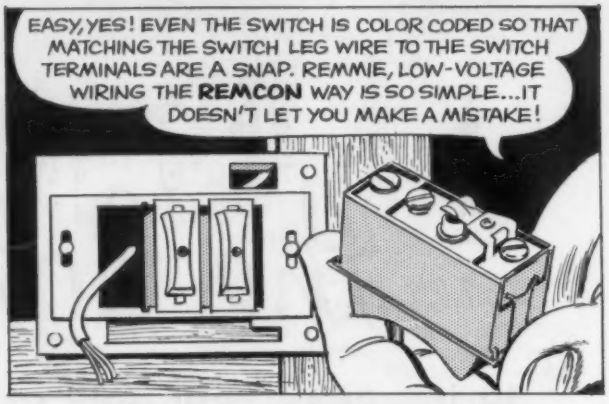
ALEC TRISHUN

"The MISSING TRANSFORMER CAPER"

REMMIE... I NAILED THE MOUNTING BRACKET TO THE STUD AND STAPLED THE #18/3 WIRE FROM THIS SWITCH LOCATION TO THE OUTLET BOX. MAN, WHAT A SNAP! BUT, WHEN DO I RUN THE WIRES FROM THE TRANSFORMER?
YOU DON'T... NOT WITH REMCON REMOTE-CONTROL WIRING.

I SEE... THE WIRING OF THE TRANSFORMER TO THE RELAY IS DONE RIGHT AT THE FACTORY. THAT REALLY SIMPLIFIES MATTERS.
YOU GOT IT, ALEC... NOW I'LL SHOW YOU HOW WE FINISH OFF THE JOB.


"HERE'S HOW EASY IT IS. JUST PULL THE LOW-VOLTAGE WIRE FROM THE SWITCH LOCATION THROUGH THE KNOCKOUT IN THE OUTLET BOX. THEN CONNECT THEM TO THE COLOR CODED LOW-VOLTAGE WIRES FROM THE RELAY. EASY, NO?"


EASY, YES! EVEN THE SWITCH IS COLOR CODED SO THAT MATCHING THE SWITCH LEG WIRE TO THE SWITCH TERMINALS ARE A SNAP. REMMIE, LOW-VOLTAGE WIRING THE REMCON WAY IS SO SIMPLE... IT DOESN'T LET YOU MAKE A MISTAKE!

AND FOR WIRING, YOU WORK WITH #18 WIRE INSTEAD OF ARMORED CABLE AND USE A MOUNTING BRACKET IN PLACE OF A SWITCH BOX
A GREAT WAY TO CUT WORK TIME AND MATERIAL COSTS.

REMCON

A DIVISION OF

PYRAMID INSTRUMENT CORP.-Dept. A2

630 MERRICK RD.

LYNBROOK, NEW YORK

DIRECT BURIAL OF TRIANGLE TRIOPRENE RR CABLE gives low-cost trouble-free systems

It wouldn't be a good practice to bury any RR cable directly in the earth where mechanical damage might cause an outage. BUT, in practically all other situations involving voltages up to 5000 volts, contractors and engineers are finding this versatile power and lighting cable pays off in installation savings and trouble-free service.

Protected by a Trioprene sheath, Triangle's special neoprene compound, RR Cable is flexible, lightweight and tough. It has good aging and heat resisting properties, and is designed to give long-time trouble-free service. It's easier to handle, splice and terminate than metallic sheathed cable. Its first cost is less, and it requires neither conduit nor ductwork under most conditions. In addition to direct burial, RR is also suitable for aerial and duct installations.

Find out more about this versatile power cable.
Write for a copy of the Triangle RR Cable folder.

Buy right—buy from your distributor

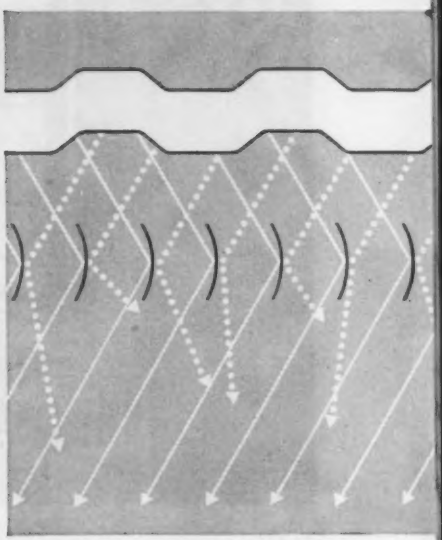
TRIANGLE CONDUIT & CABLE CO., INC.

NEW BRUNSWICK, NEW JERSEY

"It MUST Be Right!"

Smooth, comfortable illumination creates inviting appearance in store. Power-Lux installation provides over 200 footcandles using 12 Power Groove lamps.

Large-area Power-Lux luminaire combines high photometric efficiency with attractive, modern appearance.



Parabolic louvres distribute 60,000-lumen output for high-intensity, low-brightness illumination.

Over 200 footcandles with Power Groove lamps

New LPI Power-Lux luminaire for stores has been engineered for comfortable brightness using Power Groove lamps

Power Groove lamps are ideal for lighting stores when used with the new Power-Lux luminaire just introduced by Lighting Products Inc. One economical LPI Power-Lux with Power Groove lamps does the job of three conventional fixtures with slimline lamps. This lowers the cost of lighting installations as well as the cost per delivered lumen.

The very high light output of Power Groove lamps is controlled by LPI's exclusive parabolic louvres to provide high footcandle levels with comfortable brightness.

Power-Lux luminaires are available in a two-lamp model, 12 inches wide; and a four-lamp model, 36 inches wide. Both are offered in four- and eight-foot lengths. They are ideal for new stores as well as for raising lighting levels of existing commercial buildings. For re-lighting applications, Power-Lux luminaires can simply replace present fixtures to provide dramatic increases in illumination. **Get complete data on this new luminaire — write today for LPI's Power-Lux Bulletin.**

Lighting Products Inc. Highland Park, Illinois

LPI FLUORESCENT LIGHTING

ANNOUNCING

2 BIG NEW FEATURES

of TRIANGLE Hot-Dip Galvanized Rigid Steel Conduit

Completely Zinc-Coated Pipe Threads and Couplings

Protection inside and out—including the threads. No place for corrosion to start.

New, Durable Bichromate Finish!

Prevents oxidation—prevents white rust

These two new features provide even more reasons why Triangle is the choice of contractors everywhere.

Adding these two improvements in no way changes the other big features of Triangle's Hot-Dip Galvanized Conduit:

- **Triangle's 'All-Metal' Protection. No films or flash coatings to damage during installation and later.**
- **High grade ductile steel. Can be bent, cut and threaded easily.**
- **Uniformly heavy zinc deposits give full protection inside and out.**
- **Zinc applied hot doesn't flake inside or out, even if the conduit is crushed.**

When you have a tough job and the Code calls for galvanized conduit, make sure you get the best—specify Triangle.

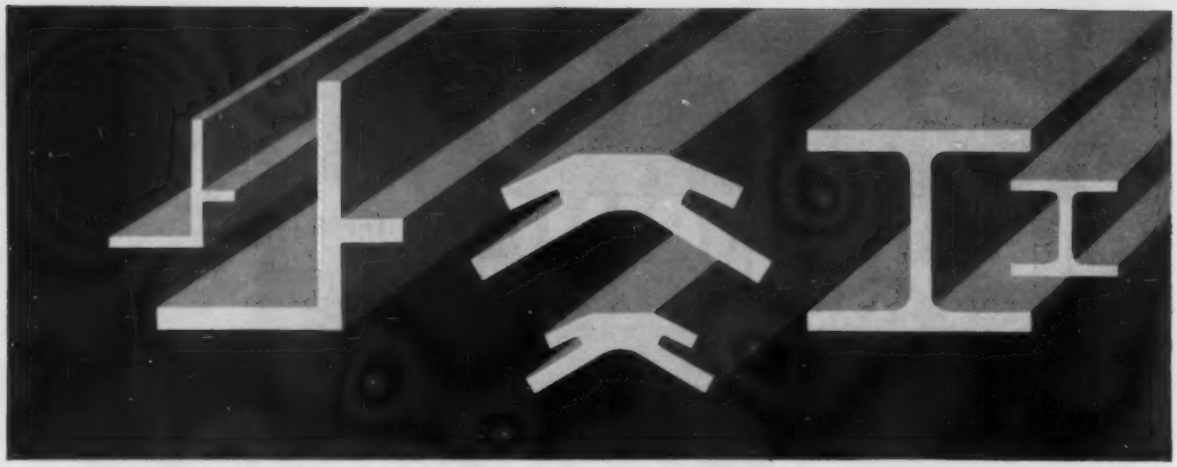
TRIANGLE CONDUIT & CABLE CO., INC.

New Brunswick, New Jersey

"It MUST Be Right!"

REMEMBER, only with Triangle Hot-Dip Galvanized Rigid Steel Conduit do you get:

STRENGTH of Steel... **PROTECTION** of Hot-Dip Galvanizing... **LONG LIFE** Assured by the Bichromate Process



now you can specify

SILVER PLATED

in almost any size or shape

Compare the cost savings of silver plated bus bar over copper

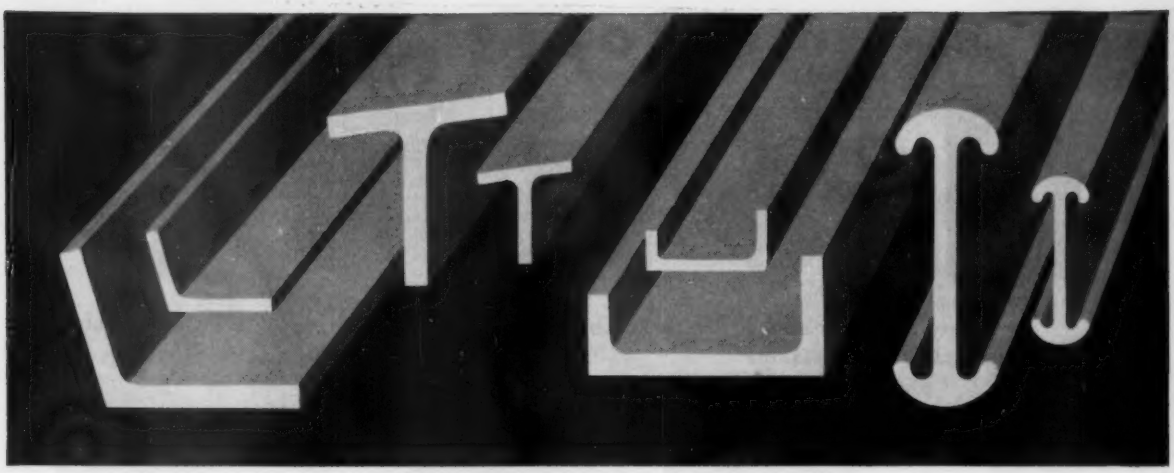
COMPARISON OF RECTANGULAR SILVER PLATED ALUMINUM BUS BARS WITH UNPLATED COPPER BARS

60 Cycle AC Ampacity (1) (Current Carrying Capacity)	Aluminum Alloy 6101-T62 30 C Rise	Copper 30°C Rise	Approx. Cost per Foot Silver Plated Aluminum 6101-T62	Approx. Cost per Foot Unplated Copper (2)
385	¼" x 1"		$ .27	
395		¼" x 1"		$ .56
420	¼" x 1½"		$ .30	
925	¼" x 3"		$ .82	
960	¼" x 4"		$ .80	
970		¼" x 3"		$1.64
1350	¼" x 6"		$1.19	
1405	¼" x 5"		$1.37	
1485		¼" x 5"		$2.29

(1) Ampacity ratings based on standard indoor conditions. (2) Based on Feb. 6, 1959, copper prices

Added strength, size and shape design advantages of Reynolds Aluminum Bus Bar have very little effect on electrical conductivity. For example, a current load of 700 amperes requires a copper bar 2" x ¼" weighing just under 2 pounds per foot; Reynolds Aluminum Bus Bar carries the same load with a 2.8" x¼" bar weighing only 4/5 pounds per foot. The result is a 60% savings in weight.

Other favorable properties of Reynolds Aluminum Bus Bar, compared with previous bus conductor materials, are an answer to electrical industry demands. Consider a ¼" x 4" aluminum bus 6101-T6 with 29,000 psi tensile in relation to a ¼" x 3" copper bus with 37,500 psi tensile and equal current capacity. With short circuit strength a direct function of tensile strength, 4 times 29,000 psi for Reynolds Aluminum Bus Bar indicates short circuit strength in excess of copper at 37,500 psi times 3. In addition, the smaller temperature coefficient of resistance for Reynolds Aluminum Bus Bar tends to improve its current carrying capacity; and the skin-effect resistance ratio is much lower than for copper.



BUS BAR (OR PLAIN BUS BAR)

from Reynolds

Here's a double story: design versatility plus silver plated bus bar economy. You can choose from Reynolds wide range of standard extruded bus bar shapes and sizes to meet a specific installation need without specifying oversize conductors because of intermediate size limitations. In addition, Reynolds can extrude special shapes and sizes in practically unlimited range to meet your most exacting requirements. This versatility permits designing to the minimum amount of metal needed for the current carrying job. The result is material costs lower than any other bus conductor.

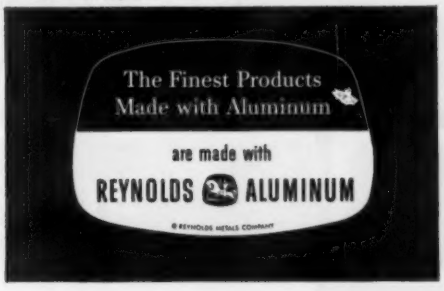
And with Reynolds Silver Plated Bus Bar, you get a surface that permits higher operating temperature with bolted joints; simplified soldering. Silver plated bar also offers savings of 35 to 50% over bare or plated copper conductors. Thus you get optimum strength, high conductivity, simplified installations, design freedom—all at low cost.

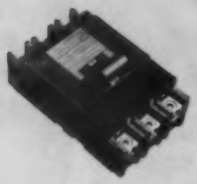
Many extruded shapes because of sharp corners and shadow areas are not readily adaptable to a high quality silver plating. Such sections are subject to special inquiry.

REYNOLDS ALUMINUM

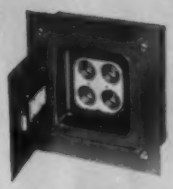
Watch Reynolds TV show—"WALT DISNEY PRESENTS"—every week on ABC-TV

For details and availability data, write today for the new brochure, "Reynolds Silver Plated Aluminum Bus Conductors", *Reynolds Metals Company, P. O. Box 2346-ET Richmond 18, Virginia.* For assistance from Reynolds Engineering Service call your nearest Reynolds office or write to the above address.



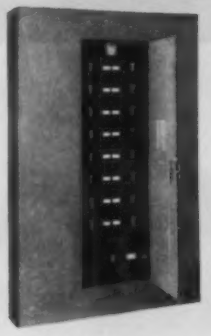


• Safety Switches and Industrial Circuit Breakers



• Fusible and Circuit Breaker Load Centers

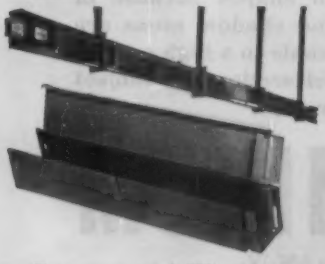
• Voltage Testers



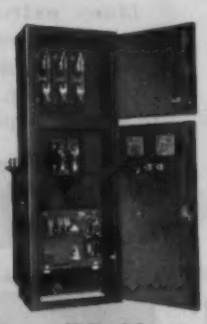
• Fusible and Circuit Breaker Lighting and Power Panelboards

• Power Distribution Switchboards and Switchgear

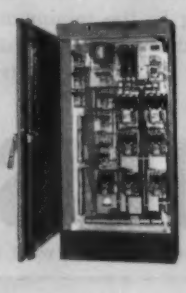
Wherever Electricity



• Busways and Wireways



EC&M High Voltage and Synchronous Starters



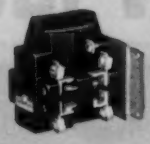
• Special Purpose Control

• Control Centers

SQUARE D COMPANY

• A.C. Manual and Magnetic Starters

• Drum Switches

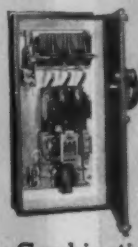


• Control Relays

• Timing Relays

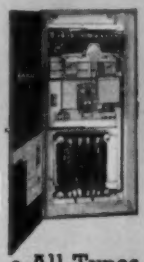
• Limit Switches

• Pushbuttons

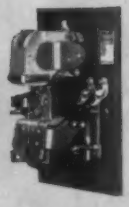


• Combination Starters

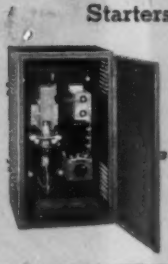
• Manual Compensators



• All Types of Reduced Voltage Starters



• D.C. Starters

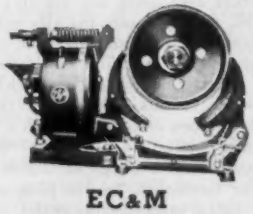


• Electronic and Electro-Magnetic Welder Control

• Float & Pressure Controls for Pumps & Compressors

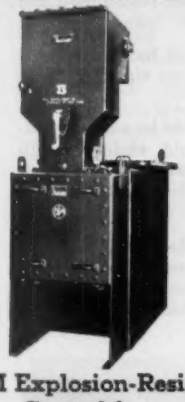
is Distributed and Controlled

EC&M
Lifting Magnets

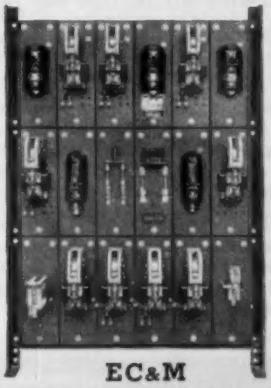


EC&M
Magnetic Brakes

FIELD ENGINEERING SERVICE
available through Square D branch offices
in all principal United States cities
... and in Canada, Mexico and England



EC&M Explosion-Resisting
Control for
Petroleum Industry



EC&M
Crane and Mill Control

DESIGN LEADERSHIP FOR MORE THAN 50 YEARS

4 new ideas in power distrib

New Switchboard

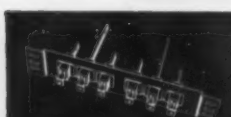
For 600-volt, maximum service, 50-100,000-ampere short circuit rating

Standardization is the keynote in this new Type DR switchboard. Standardization provides greater flexibility, easier installation and more maintenance features than ever before—*at lower total cost.*

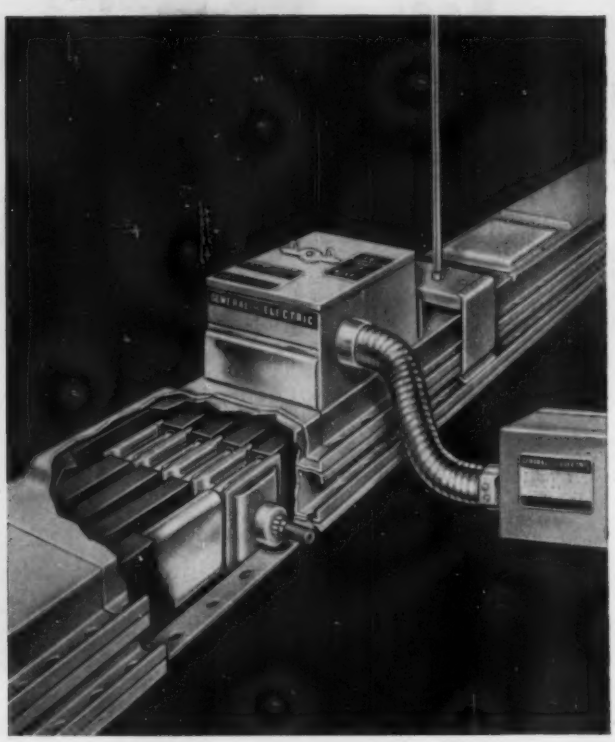
Standardization, for example, enables the DR to incorporate any combination of seven protective devices—fusible or circuit breaker types—with complete interchangeability.

Standardization allows units or whole sections to be added, interchanged or removed—quickly, easily—in the field, as load conditions change, and with minimum time and effort. Pre-drilled, pre-formed modular framework and bus bars virtually eliminate the need for field drilling.

For installation and maintenance ease, standardized, centrally located horizontal main busing leaves the top and bottom of the DR clear for busway or cable entrance. No braces or bars to interfere with wiring. All terminals are easily accessible. Ask for a copy of Bulletin GEA-6627.



DR SWITCHBOARD EXTRA VALUE
New stud assembly. Eliminates wire bending—allows "straight-in" wiring—opens up more working space to speed installation. Stud assemblies are mounted on a strong, light-weight, non-magnetic aluminum barrier which minimizes heating.



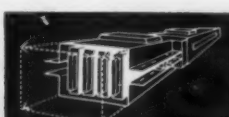
New Busway

ampere for ampere, the smallest, lightest, most efficient and rugged ever designed

New Type DE busway is a totally enclosed plug-in busway with 50,000-ampere short circuit capacity as standard. It is rated 225-1000 amperes, 600 volts maximum, 3 pole or 4 wire, 3 phase. New Type DE busway incorporates all *22* features that engineers, contractors and users say are important in busway design.

DE, for example, installs with unmatched ease. It is up to 50% lighter and 30% smaller than other busways of comparable rating; approved for hanging on 10-foot centers in any position. Sections are electrically joined—quickly, simply—by means of a unique one-bolt, vise-like mechanism that maintains positive electrical contact between conductors with a ton of force. And DE's miniaturized fittings virtually eliminate the need for custom engineering. Result: 30% average saving in installation cost and 10% over-all.

For flexibility, twelve plug outlets come in each 10-foot length. For extra safety, each outlet is virtually dead-front and traveling arcs are essentially eliminated—thanks to Butyl insulation which is extruded over the full length of each bus bar, overhanging bus plug openings. Ask for a copy of Bulletin GEA-6173.



DE BUSWAY EXTRA VALUE
DE busway's telescoping length allows one-foot adjustment (between 36 and 48 inches), precluding need for exacting layout, custom engineering, or special fabrication.

See your G-E representative or distributor for complete information. You may also obtain complete information on this equipment by writing to General Electric Company, Distribution Assemblies Department, Plainville, Conn.

ution offer more for the money

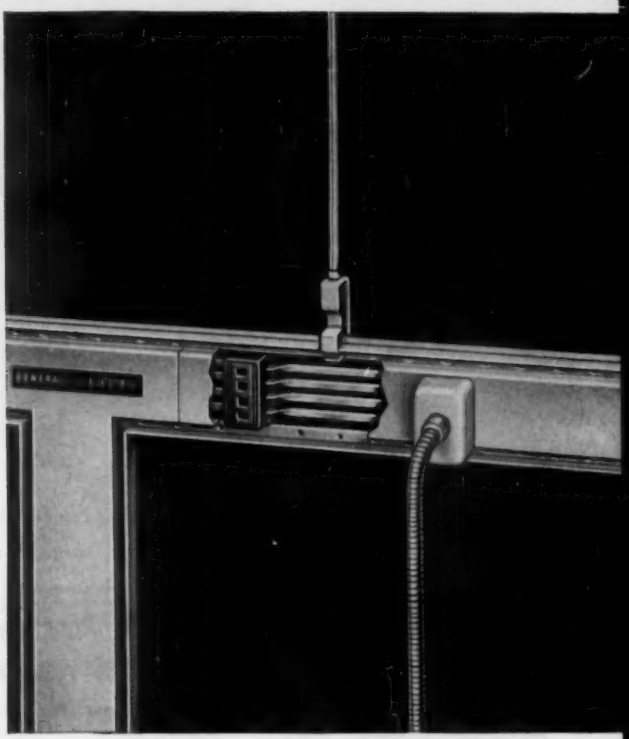
New Control Center

conserves space, costs less to install, saves money in operation

New compact Type DA7093 Motor Control Center provides an economical, centralized control of A-C motors, up to 200 hp at 600 volts (100 hp at 240 volts).

Compared with individual motor control, initial equipment investment with Type DA7093 is usually substantially lower. At the same time, the '93 affords convenient, economical plant operation and low maintenance. And when load requirements change, the '93 is easily expanded to meet them with standardized plug-in control units in NEMA sizes 1 through 5. Other components, such as meters, instruments, relays and panelboards can be built-in to meet specific needs.

Location of main buses at center of section allows wide, unobstructed pull-box space at top and bottom for easy wiring. Bus bars are silver-plated for positive electrical contact and edgewise mounted for optimum short circuit strength. Standard main bus ratings are 600 or 1200 amperes. Bus bars are braced for fault levels of 25,000 or 50,000 amperes. Ask for Bulletin GEA-6367A.



New Busway

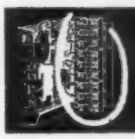
100-ampere plug-in design hailed as the "Wiring Method of Tomorrow"

Now, a plug-in busway that costs no more installed—and usually substantially less—than wire and conduit!

Or as a leading electrical contractor in Wilmington, Delaware, puts it: "With Type DH, I can save 25% over the cost of conduit and wire when there are four or more tap-offs in the system."

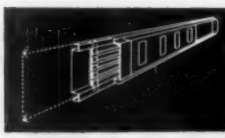
Type DH—rated 100 amperes, 3 pole or 4 wire, 3 phase, 600 volts maximum—serves as either a feeder or plug-in system and may be used wherever exposed wire and conduit might be applied. Light, sturdy and small in size (in cross-section not much larger than a pack of king-sized cigarettes), DH may be hung edgewise on 10-foot centers. Eighteen dead-front outlets are provided in each 10-foot length. For added flexibility, each outlet accepts a variety of fusible, no-fuse and circuit breaker plugs.

G-E distributors, *nationwide*, stock Type DH, including its wide variety of fittings and accessories. So DH matches wire and conduit in *availability* as well as cost. Ask for Bulletin GEA-6172.



MOTOR CONTROL CENTER EXTRA VALUE

Split Type B terminal blocks (circle) provided on each control unit permit quick, convenient removal of unit without disturbing load and control wiring.



DH BUSWAY EXTRA VALUE

Telescoping length adjusts between 42 and 54 inches. This, plus flexible fittings, eliminates need for exact measurements. Rigid fittings—elbows, crosses and tees—adapt busway to virtually any building contour.

GENERAL ELECTRIC

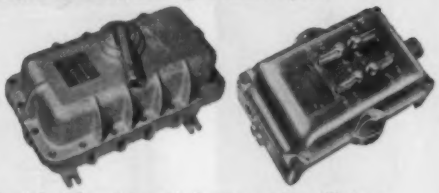
When you install
be sure to use Killark

the *first* and most complete all-

MOTOR STARTER ENCLOSURES
Explosion-Proof, Dust-Tight, Weatherproof

Starters and Combination Starters Made to Order

CIRCUIT BREAKER ENCLOSURES
Explosion-Proof, Dust-Tight, Weatherproof

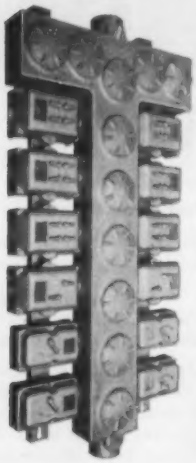


Furnished Complete with Breaker of Your Choice

JUNCTION BOXES
Explosion-Proof, Dust-Tight, Weatherproof

More Than 40 Sizes Custom Hubs

PANEL BOARDS
Explosion-Proof, Dust-Tight, Weatherproof



Completely Wired—Ready to Install

ENJOY THE *Plus* ADVANTAGES OF A *100%* ALUMINUM INSTALLATION!

- **Lightweightness.** You save labor, cut transportation and handling charges. Aluminum weighs ⅓ as much as iron; one man can handle an all-aluminum installation which may have required two men when other metals are used.
- **Ease of Installation.** Aluminum conduit bends without collapsing, shapes up quickly. Killark fittings have clean threads and plenty of wiring room—and are designed for easy installation.
- **Non-Sparking.** An important safety factor in hazardous areas.
- **Non-Rusting, Non-Corroding.** Exclusive Killark aluminum fittings are long on life, short on maintenance. Smooth, bright, clear-through durability; they never rust and are more corrosive resistant than other types.

Make your next installation an *all* aluminum one—aluminum conduit and 100%-aluminum Killark fittings. The best costs less in the long run.

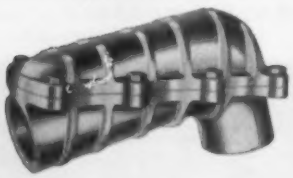
INSTRUMENT BOXES
Explosion-Proof, Dust-Tight, Weatherproof

Several sizes Glass Lens Covers Available

SPLICE BOX Explosion-Proof

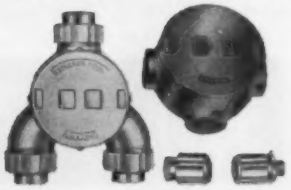
Available 1¼"—1½"—2" with Various Hub Styles

PULLING ELBOW
Explosion-Proof



Very Rugged Construction Various Sizes

FITTINGS Explosion-Proof



Complete Line of Fittings & Accessories

Killark

KILLARK ST. LOUIS

ELECTRIC MANUFACTURING COMPANY

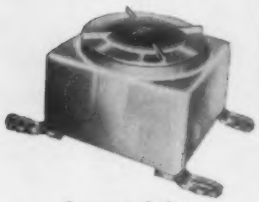
Vandeventer and Easton Aves. • St. Louis 13, Missouri

Aluminum Conduit...

ALUMINUM FITTINGS AND FIXTURES

aluminum line!

JUNCTION BOXES
Explosion-Proof



Screwcap Style
Many Sizes—Custom Hubs

DUST-TIGHT FIXTURES

Available in
Pendant,
Bracket &
Ceiling Types
100W—150W—200W

VAPOR-PROOF FIXTURES

Pendant,
Ceiling,
Bracket Types.
60W to 500W.

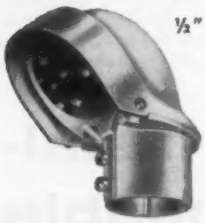
EXPLOSION-PROOF FIXTURES

Available in
Pendant,
Bracket &
Ceiling Types.
60W thru 500W.

FLUSH SWITCH FITTINGS
Single thru 5-Gang
Shallow &
Deep Styles

ENTRANCE FITTINGS
Threaded and Speedolet Types

½" thru 6"



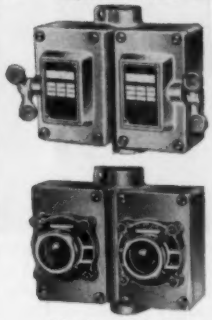
...AND ENJOY THE *Completeness* OF THE KILLARK LINE!

Whatever the installation, Killark can provide the correct aluminum fitting or fixture. That's because Killark has been supplying the electrical needs of contractors for over 45 years. In 1942, Killark pioneered the use of aluminum and now manufactures exclusively the *only* complete line of aluminum fittings and fixtures. *They cost no more than malleable iron fittings.*

There are thousands of fittings in the constantly expanding Killark line. Many years of research, design and development are your assurance of the finest aluminum fittings at the lowest possible cost. Fast delivery is assured through convenient warehouse stocks in many cities.

THE KILLARK ILLUSTRATED CATALOG IS YOURS ON REQUEST

SWITCHES—PILOT LIGHTS
Explosion-Proof, Weatherproof



Switch

Pilot Light

Single and 2-Gang

PLUGS & RECEPTACLES

Complete Line
Explosion-Proof
and Weatherproof

CLUSTER LIGHTS

150W to 500W.
Versatile in Design

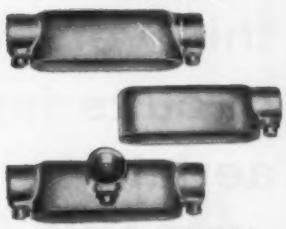
KILLARK REPRESENTATIVES

*Atlanta, Ga.
Baltimore, Md.
*Boston, Mass.
*Buffalo, N. Y.
*Chicago, Ill.
*Cincinnati, Ohio
*Cleveland, Ohio
*Dallas, Tex.
*Denver, Col.
*Detroit, Mich.
Kansas City, Mo.
*Los Angeles, Calif.
Milwaukee, Wisc.
Minneapolis, Minn.
New York City, N. Y.
Omaha, Neb.
*Philadelphia, Pa.
*Phoenix, Ariz.
*Pittsburgh, Pa.
Richmond, Va.
*San Francisco, Calif.
*Seattle, Wash.
Honolulu, Hawaii

Sales Offices and Warehouse Stocks throughout Canada

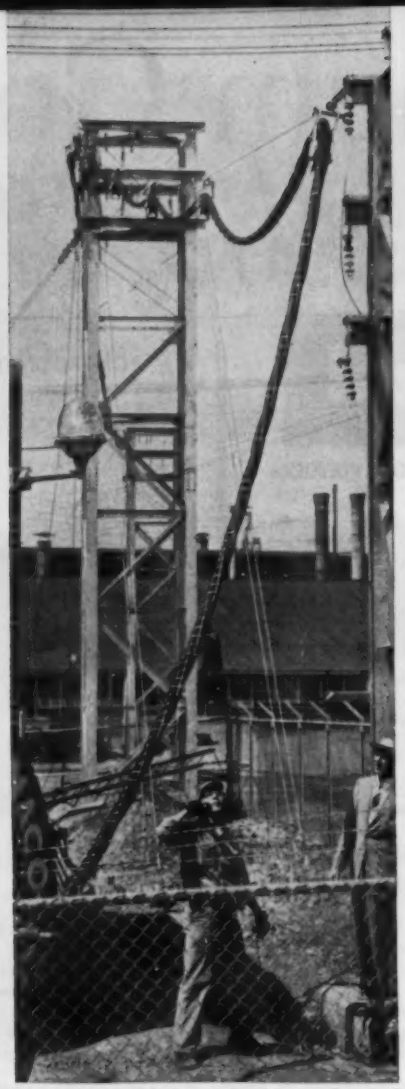
*Warehouse Stocks

SPEEDOLETS



For Thinwall Conduit
All Sizes thru 2"

Quickly installed aerial cable. Here's an application where 600-volt Durasheath was quickly installed and easily terminated. Durasheath's neoprene jacket resists weather, abrasion, heat, fumes. Assured: dependable performance and long-range economy!

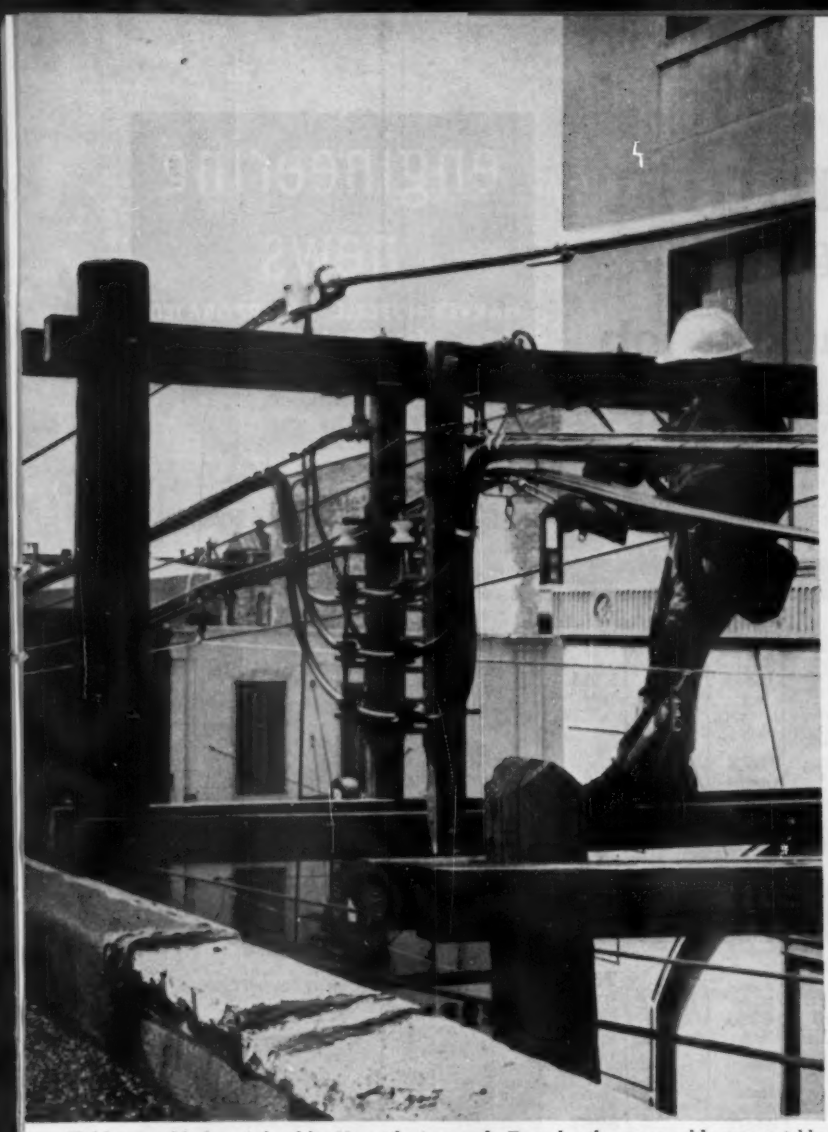


Factory-assembled aerial cable, made up of 3 single-conductor 15-kv Durasheath cables. Easy splicing, tapping and terminating meant simplified installation in the job shown here. No ducts, crossarms or insulators were needed. Wiring is neat, safe.

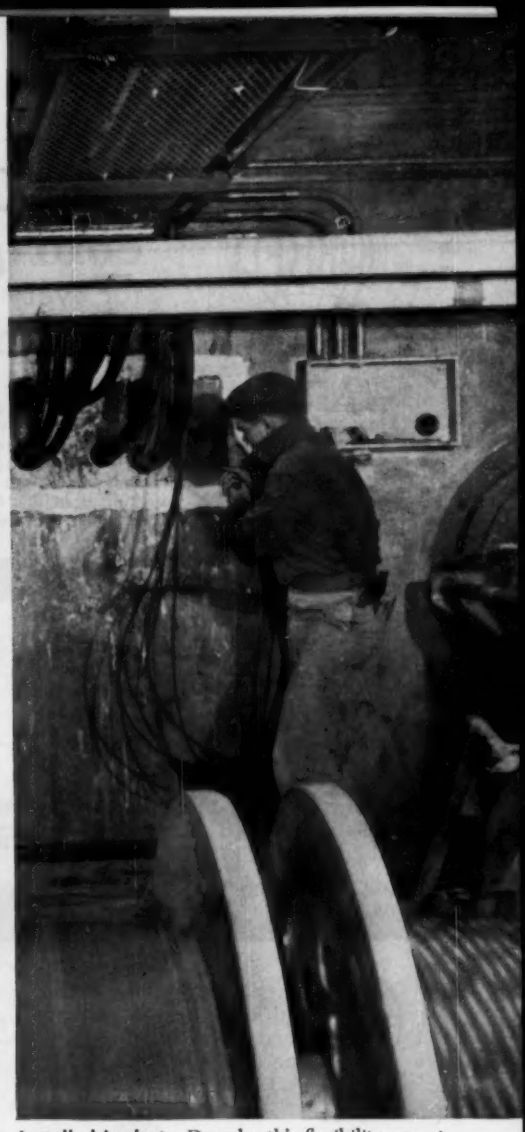
Direct-burial cable. The moisture-, oil-, and acid-resistance of Durasheath's jacket makes it the ideal cable for direct-in-the-ground applications like the one shown above. Its flexibility cuts installation time and cost because Durasheath is easy to handle. Its durability cuts maintenance costs!

Look at the ways you can save installation time and cost—with dependable Anaconda Durasheath Cable!

Wherever you want...whenever you want—this versatile power cable lets you install circuits fast... easily... at low cost! Use it aerially... in ducts... underground—in long runs with minimum splicing, indoors or out!



Field-assembled aerial cable. Versatile Anaconda Durasheath power cable was quickly field-assembled into aerial cable with the simple spinning operation shown here. Additional Durasheath was run along the building, grouped in a neat assembly by insulators and straps. It's another example of the way dependable Anaconda Durasheath adapts itself to your power cable needs—whether indoors, outdoors or both. Check into Anaconda Durasheath power cable for your wiring plans!



Installed in ducts. Durasheath's flexibility meant quick and easy installation here. And once installed, its tough neoprene jacket assures long, trouble-free life. Because Durasheath adapts itself to so many uses, your inventory problems are lessened—fewer cables need be carried in stock!

The installations shown above have one thing in common: they're all using Anaconda Durasheath* rubber-insulated neoprene-jacketed power cable —each for a different *kind* of application! Although the above photographs were taken at different installations, they could very well be pictures from one and the same job. Versatile Durasheath is a power cable that can be used to meet almost *any* installation need!

Such versatility in the use of Durasheath enables you to plan the most efficient layout for your wiring – then carry these plans through economically, with assurance of reliability. Talk to the Man from Anaconda about Durasheath. For full information, write: Anaconda Wire & Cable Company, 25 Broadway, New York 4, New York.

*Trademark

58376 Rev.

ANACONDA DURASHEATH ALL-PURPOSE POWER CABLE
Available in all sizes, single and multiple conductor, copper or aluminum, 600 to 15,000 volts and higher.

Insulation. Type RHW, Anaconda ANW, Anaconda Butyl (AB) high-voltage or Anaconda Butyl (AHW) low-voltage rubber compound.

Jacket. Specially compounded neoprene with high resistance to flame, oil, acids, alkalies, sunlight and ozone. Has high tensile strength. Takes flexing at extremes of temperatures.

SEE THE MAN FROM

ANACONDA®

FOR DURASHEATH CABLE

IT PAYS TO HAVE GOOD CONNECTIONS — HUBBELL

...the RIGHT configuration for every grounding job

Ever since 1947, when the Schirmer report cited the "shocking" need for adequate grounding, Hubbell has been developing and adding to their grounding device line. As new code requirements were introduced, new wiring device configurations were designed to prevent accidental interchange between units of different ratings. Here are the many faces of Hubbell's grounding family. By presenting it in this form we hope to clarify this subject and aid you in specifying the right unit for the job.

15 Amps., 125 Volts

Parallel Blade **5262** Type

"Twist-Lock" For Grounding Only **4700** Series

15 Amps., 125 Volts

5261 Type with **7572** Type Standard 3-Wire, 10 A., 125 V. "Twist-Lock" — **7369**

5261 Type with **4700** Grounding "Twist-Lock" — **4792**

15 Amps., 250 Volts

Tandem Blade **5661** Type

15 Amps., 277 Volts

"Twist-Lock" For Grounding Only **4750** Series

15 Amps., 125 Volts
15 Amps., 250 Volts

Parallel Blade **5261** Type with Tandem Blade **5661** Type — **5290**

7572 Type Standard 3-Wire 10 A. 250 V. "Twist-Lock" with Tandem Blade **5661** Type — **7375**

10 Amps., 250 V
15 Amps., 125 V

Crow Foot **7051** Type

20 Amps., 250 Volts

Crow Foot **6810** Type

15 Amps., 277 Volts

New In Development Stage

20 Amps., 125 Volts

New In Development Stage

30 Amps., 250 Volts

30 A., 250 V. **9350** Type

engineering news

HARVEY HUBBELL, INCORPORATED
Engineering Department

EVOLUTION OF 15 AMP., 125 VOLT GROUNDING DEVICES

The Schirmer Report, published in 1947, was the first comprehensive study of the prevalence and causes of electrical accidents. It indicated that accidents involving portable tools and household appliances are due primarily to two causes: one, use in very wet locations, and, two, shorted insulation in the switching mechanism.

While lack of proper grounding was not the only cause of accidents, many fatalities might have been prevented by effective grounding. Of the cases analyzed, 278 fatal accidents could have been prevented if portable equipment, drills, saws, sanders and similar tools, had been effectively grounded.

According to the report, causes of the accidents in this area were 3-fold:

1st, negligence in not wiring "pigtail" grounds furnished on 2-wire caps.

2nd, insertion of grounded attachment plug caps into receptacles wired for 3-phase circuits.

3rd, insertion of a male, 2-wire cap furnished on 125 volt appliances into receptacles wired for 250 volts.

HARVEY HUBBELL, INCORPORATED
BRIDGEPORT 2, CONNECTICUT

WIRING DEVICE OFFICE AND WAREHOUSE LOCATIONS

Bridgeport 2, Connecticut — State and Bostwick Streets
Chicago 7, Illinois — 37 South Sangamon Street
Los Angeles 12, California — 103 North Santa Fe Avenue
San Francisco, California — 1675 Hudson Avenue
IN CANADA: Scarborough, Ontario, 1160 Birchmount Road

Continued on page 199

58TH YEAR • MAY 1959

ELECTRICAL CONSTRUCTION AND MAINTENANCE

Preface

Most of the editorial content of this issue is devoted to a comprehensive book-length project, "Modern Electrical Systems Design". It is, essentially, a manual of practical procedures for the design of electrical systems serving buildings and their surrounding facilities. It is especially prepared for the engineer and the contractor who must, in the course of his professional responsibility, interpret requirements for electrical utilization, control and communication in feasible, practical and detailed plans leading to actual construction.

An important feature of the project is a systematic and thorough correlation of the successive design procedures with the requirements of the National Electrical Code. Since practically all electrical wiring and installation in buildings in the United States must comply with the provisions of the NEC, or closely related local codes, code compliance is an essential, and often decisive, consideration at every step of practical system design.

Emphasis is also given to current engineering practice and evident trends to the exclusion of merely theoretical possibilities. The design and procedures outlined deal entirely with materials and equipments generally available through the conventional trade channels of the industry. Data involving voltage are based upon supply and circuit voltages in common use in the United States.

In its original form "Modern Electrical Systems Design" appeared in our May 1956 issue. It promptly evoked a great many complimentary comments from our readers and in spite of a substantial over-run, the entire issue was sold out in a few weeks. It was subsequently published as a hard-cover book. Since that time it has had the benefit of many helpful and constructive comments and suggestions. This edition is an extensive revision including greatly expanded coverage in scope and detail of specific design problems.

We are particularly proud to note that this project has been produced entirely by our own editorial staff. While every member of the staff has contributed in some way, it has been written mainly by J. F. McPartland, Jr., with a special assist in two chapters from B. C. Cooper and W. J. Novak. All are experienced electrical engineers in daily contact with current activities in the field of electrical construction. The following pages are ample testimony to their professional competence, as editors, and in the technology of the field they serve.

Wm. T. Stuart

"If you need it, we have it!"

Walk in to any Graybar counter and you'll find the lines complete. That's mighty important when you want to move fast, or meet tough specs.

You'll also find the wide range of electrical items that makes it practical to buy from one source . . . motors, controls, conduit, fittings, everything from the newest in lighting fixtures to the wiring materials you need for the bread and butter jobs. There's real technical help. Orders are assembled fast. There's even a phone handy – for your use.

Moreover, the Graybar Counterman is but one of several well trained men on the Graybar electrical contractor service team. The others are: Inside Salesman, Field Salesman, Specialists. The job of all of them: to *reduce your costs, speed your work,* help *build your business.*

Isn't it about time you tried Graybar? Call us. See how fast we move for *you.*

917

Graybar Service includes: Objective recommendations. On-the-job technical help. Most complete lines. Planned stocks to meet your needs. Expert counter service. Speedy handling of will-calls.

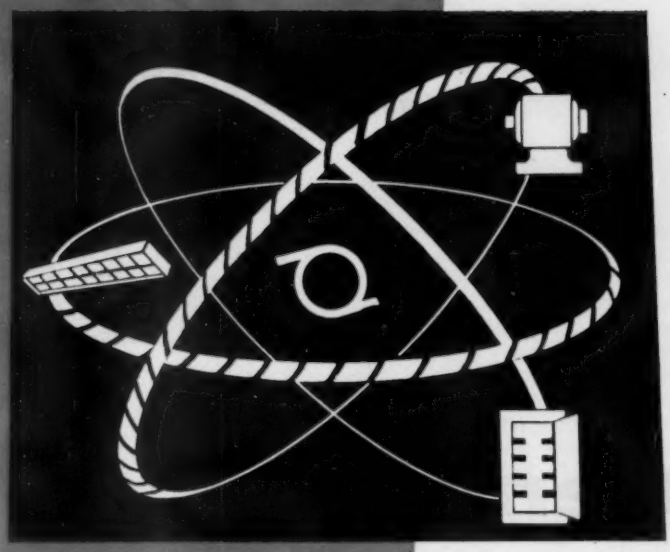
GraybaR

ELECTRIC COMPANY, INC.

Everything Electrical GraybaR Electric Company

420 LEXINGTON AVENUE, NEW YORK 17, N. Y. • OFFICES IN OVER 130 PRINCIPAL CITIES

ELECTRICAL
CONSTRUCTION
AND MAINTENANCE

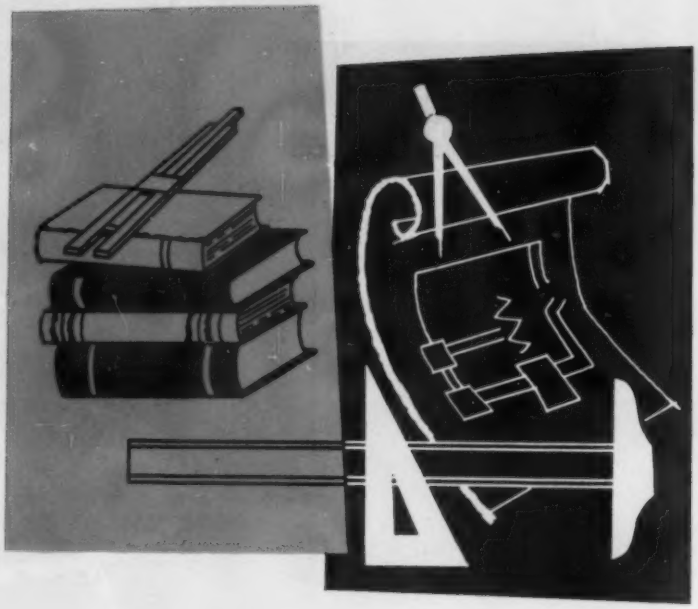


A practical manual on . . .

MODERN ELECTRICAL DESIGN

CONTENTS

General Considerations 114
Branch Circuits 120
Distribution System 148
Service Layout 181
Residential Wiring 193
Modern Lighting Design 203
Heating and Air Conditioning 235
Signals and Communications 257



General Considerations

SIMPLY stated, electrical design for industrial, commercial and institutional buildings is a matter of providing for the transfer of power from a source (or sources) to various utilization loads. This involves selection and layout of circuits to feed the loads, a distribution system to serve the circuits and suitable switching and protection arrangements for the incoming power supply lines. This basic procedure can be reduced to three steps to design of any electrical system as follows:

A. Select basic wiring concepts and configurations which will supply electrical power of the required characteristics at each point of electrical utilization, including circuit and distribution designs which will provide satisfactory transfer of power from source to loads to meet prevailing requirements.

B. Implement the electrical circuiting concepts with actual conductors, apparatus and hardware, selecting types, sizes, models, characteristics, appearances, ratings and other specifics of the required equipment.

C. Account for the installation of the overall electrical system, as determined from the first two steps, within the physical dimensions and structural makeup of a building, showing, as clearly as possible, locations and details of equipment mountings, raceway runs, connections to main power supply lines and whatever elements require special attention.

Of course, these three steps are necessarily interrelated, and particular decisions made within any one step will affect corresponding elements within either or both of the other steps.

As can be seen from the three steps, design of an electrical system is expressed in the form of electrical plans. All phases of a design, including design of sub-systems within the major system, should be reduced to a set of blueprints which present schematic wiring diagrams, single-line diagrams, full-wiring hookups, riser diagrams, isometric and other sketches, detail drawings and equipment schedules —all as necessary to convey a clear picture of the system to the installer.

But before the actual design work begins, there are many factors which must be considered and understood in their relation to the contemplated design of an electrical system.

The Right Approach

Successful electrical design for all types of modern buildings depends first of all upon the right approach. The electrical designer must be thoroughly familiar with all of the background factors of design. He must, of course, have depth in engineering ability. But over and above this he must also fully understand the relation between pure technology in an electrical system and such considerations as safe application, capacity for load growth, flexibility in use of the system and effective layout. From such understanding, the right approach to electrical design is inevitable.

Then the right approach must be correlated with

modern standards. Because electrical design is a dynamic thing—the continually evolving product of years of accumulating technology—the electrical designer must learn the new techniques and follow the promising trends. Electrical design is not a mechanical procedure for merely filling in formula and adding parts together. It involves clear understanding of old, accepted techniques and the reasons why those techniques survived the test of years of application. It requires combinations of old and new wiring techniques and the ability to devise original circuits and layouts for new or special equipment applications. In short, it demands that the designer be as dynamic as the art and science he practices. Only from an all-around grasp of the subject can a designer exercise judgment in selection of circuit and feeder arrangements, equipment types and ratings and installation methods.

System Characteristics

In general, there are five basic considerations which should precede initiation of actual design work. These concern:

1. Safety
2. Capacity
3. Flexibility
4. Accessibility
5. Reliability

These are considerations involving use of the electrical system after it is completed. They recognize that a system must provide power and light without hazard to life or property, with sufficient extra capacity to meet foreseeable load growth, with ready adaptability to load modifications and revised layouts and with all necessary accessibility in the distribution arrangement.

Safety

Compliance with the provisions of the National Electrical Code can effectively minimize fire and accident hazards in any electrical design. The code (throughout this manual, the word "code" refers to the National Electrical Code) sets forth requirements, recommendations and suggestions and constitutes a minimum standard for the framework of electrical design. As stated in its own introduction, the code is concerned with the "practical safeguarding of persons and of buildings and their contents from hazards arising from the use of electricity for light, heat, power, radio, signalling and for other purposes."

Although the code assures minimum safety provisions, actual design work must constantly consider safety as required by special types or conditions of electrical application. Incorporation of automatic protective devices and selection of control equipment for particular applications involves engineering skill of the designer, above routine adherence to code requirements. Then, too, the designer must know the physical characteristics—application advantages and limitations—of the many materials he uses for enclosing, supporting, insulating, isolating and, in general, protecting electrical equipment. The task of safe application based on skill and experience is particularly important in hazardous locations. Safety is not automatically made a characteristic of a system by simply observing codes. Safety must be designed into a system.

The NE Code is recognized as a legal criterion of safe electrical design and installation. It is used in court litigation and by insurance companies as a basis for insuring buildings. Because the code is such an important instrument of safe design, it must be thoroughly understood by the electrical designer. He must be familiar with all sections of the code and should know the accepted interpretations which have been placed on many specific rulings of the code. He should keep abreast of official interpretations which are issued by the NE Code committee. He should know the intent of code requirements—i.e., the spirit as well as the letter of each provision. He should keep informed on interim amendments to the code. And, most important, he should keep this code book handy and study it often.

In addition to the NE Code volume itself, the electrical designer should have on hand and be familiar with other standards and recommended practices made available in pamphlet form by the National Board of Fire Underwriters. These cover such special subjects as: Hospital Operating Rooms, Municipal Fire Alarm Systems, Garages, Aircraft Hangars and similar special applications with great potential hazards due to improper design.

Every electrical designer must also be familiar with insurance company regulations and all local codes which affect a particular installation. He should know in detail where and how local codes depart from the NE Code. Again he must understand the basis for special provisions to assure most effective conformity throughout a system. Often, a local condition which requires special code rulings has a significant effect upon the entire design.

Still another measure which a designer can take to enhance the safety characteristic of his work is regular use of literature issued by the Underwriters' Laboratories, Inc. The UL examines, tests and determines the suitability of materials and equipment to be used according to code regulations. Each year, the UL publishes three volumes which are essential as references for electrical designers. These are listings of commercially available electrical products which have been found acceptable with reference to fire and accident hazards and in conformity with the application and installation requirements of the code. The three volumes are entitled as follows:

1. "Electrical Construction Materials"
2. "Electrical Appliance and Utilization Equipment"
3. "Hazardous Location Equipment"

The UL also has other literature on special equipment involving hazard to life or property, such as "Gas and Oil Equipment" and "Fire Protection Equipment."

Capacity

In general, every electrical system should have sufficient capacity to serve the loads for which it is designed, plus spare capacity to meet anticipated growth in the load on the system. In particular, this means that conductors and raceways must be sized liberally for computed loads; substations, transformers and switching and protective devices must have the needed capacity and ratings. And spare capacity throughout the branch circuiting should be reflected back through the entire electrical system to the point of power supply.

Allowance for load growth is probably the most neglected consideration in electrical design today. Although the code contains an almost obscure recommendation that electrical plans and specifications include "allowances for future increases in the use of electricity", experience with current electrical modernization practice indicates that lack of spare capacity plagues existing systems. In all types of buildings, conduit risers are filled to capacity and the conductors in them are either loaded fully or overloaded. In most commercial and institutional buildings, the entire electrical system is at or near saturation—in branch circuits, feeders and service. And in the majority of these buildings, modernization of the existing electrical system to handle increased load demands is impeded by absence of space in which new risers and circuits might be run. It is obvious that overall design of these electrical systems did not account sufficiently for future load growth.

Modern electrical design, therefore, must carefully plan for future increase in electrical utilization. Depending upon the particular conditions in any installation, mains, switchgear, transformers, feeders, panelboards and circuits should be sized to handle considerable load growth. Conductors should be selected on the basis of carrying capacity, voltage drop and estimated future requirements. Conduit, wireways, troughs and other raceways should be sized to allow future increase in occupancy. And space used to house electrical equipment—electric closets, switchgear rooms, substation cages, riser and pipe shafts, etc.—should also be able to accommodate the addition of more equipment at a later date.

Flexibility

Depending upon the type of building—industrial, commercial or institutional—the electrical system must be designed to provide required flexibility in distribution and circuiting. Layout and type of equipment should readily accommodate changes in locations of motors and other utilization devices. Feeders, distribution panelboards and circuits should be suited to a wide range of utilization patterns, allowing full and efficient use of power capacity for activities in the building's various areas.

Accessibility

Every electrical system should rate high in accessibility. In its final form, design of the system must provide ease of access to equipment for maintenance and repair and for any possible extensions, modifications or alterations in the system. The system of conductors, raceways and equipment must allow for full use of its power handling ability.

Reliability

Depending upon the nature of activities in a building, continuity of electrical supply and overall reliability of the wiring system itself can be a more or less important consideration. Where electrical utility companies have a good record of supply continuity and temporary loss of power would not be a direct life or property hazard, special provisions for a separate emergency power supply are usually not necessary. But in many industrial plants, hospitals and buildings with essential equipment electrically powered, standby power plants or multiple services must be used for absolute reliability of supply.

Pre-Design Factors

Based on full recognition and appreciation of the foregoing system characteristics, electrical design for a specific building begins with analysis of the type of building, its loads and the source of supply. This involves careful determination of all usual and special electrical requirements for the type of building. Consideration must be made of the activities performed in the building and the nature of electrical usage by the occupants. Whether the building is a school, an office building, an industrial plant, a hospital—the designer must know the history of electrical application in the type of building and must be well informed on current trends and practices.

Nature of Building

The general design approach to any contemplated electrical system takes into account characteristics of the building—small or large, single-story or multi-level industrial plant; high office building; apartment house; single- or multi-level school; hospital; etc.—as this gives insight to types of electrical utilization, need for flexibility, accessibility of the system and the duty cycles of various load devices. The many and varied considerations for hazardous locations also serve to give direction to design approach. From the general approach, the mind of the designer should have selected many design possibilities which suit the particular building and have rejected all methods and techniques which are immediately not applicable.

In general, planning for design of an electrical system should begin with determining and studying the size and nature of the total load to be served. This means approximation of lighting loads on the basis of watts/square foot, analysis of number and sizes of motors served in various areas of the building and determination of amount of other utilization loads and their concentrations throughout the build-

ing. Full understanding of all loads—their values and points of application—is essential to selection of the best type of distribution system.

Equipment Selection

Maximum standardization in equipment type and ratings should always be a design objective. Selection of standard supply voltage and standard values at all voltage levels is a significant economy factor in that standard rated transformers, switchgear, motors and other equipment cost less than special equipment for non-standard voltages.

Lack of standardization in an electrical system complicates maintenance in that replacement parts are not easy to get, inventory of parts and equipment is high and the efficiency of maintenance personnel is reduced. And the use of special, non-standard equipment and voltages may seriously impair expansion or alteration of the electrical system at a later date.

Source of Supply

Another preliminary consideration which fundamentally affects design procedure involves the characteristics of the power supply which will serve the building's electrical system. The power supply may be either the distribution system of the electric utility company or a private electric generating plant.

Checklist of Design Details

1. Lighting Loads

a. Sizes and types of luminaires
b. Layout of luminaires
c. Circuits and wiring
d. Switching hookups
e. Branch circuit panelboards
f. Emergency lighting layouts
g. Special layouts—floodlighting, stage lighting, etc.
h. Layout and circuiting of plug outlets

2. Power Loads

a. Sizes and types of motors, motor-operated devices and/or heating units
b. Layout of power loads and circuits
c. Disconnect and controller equipment
d. Overcurrent devices: circuit-breakers, fuses, relays—for overload and short-circuit or ground faults
e. Motor control centers
f. Power panelboards
g. Emergency power provisions

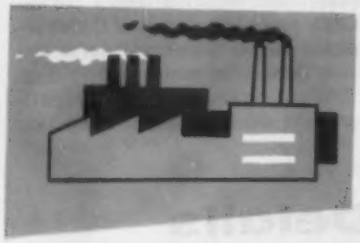
3. Distribution

a. Power and lighting panelboard loads
b. Sizes and types of feeders
c. Sub-distribution: panelboards, switchboards, overcurrent devices, disconnects, conductors
d. Load-center substations, transformer banks
e. Primary feeders, overcurrent devices, disconnects
f. Type of distribution system: radial, loop, secondary selective, primary selective, spot network
g. Service layout: sizes and types of service disconnect and protection equipment, switchgear, transformers, metering arrangements
h. Connections of system to source of electric power supply (service conductors—overhead, underground)

4. Signalling and Communications

a. Telephones
b. Intercom, paging, music distribution
c. Clock and program systems
d. Alarm systems
e. Special control systems: e.g., carrier freqency (wireless control)

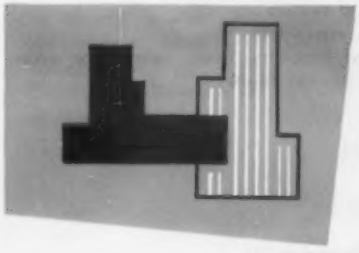
Modern Design Elements



industrial plants

Varying with the particular type of industrial operation, electrical load density can run well over 20 watts per square foot. Typical modern elements of industrial electrical systems include the following:

—Primary distribution to load center substations.
—Interlocked armor cable feeders rated for 5-kv or 15-kv circuits.
—Extensive use of 480-volt power and 277-volt fluorescent and/or mercury vapor lighting.
—Busway and/or interlocked armor cable for secondary voltage feeders.
—Cables troughs and/or racks carrying suitably protected cables, for maximum system flexibility and accessibility.
—Underfloor power ducts for flexible circuiting to machine loads throughout widespread plant areas.
—Plug-in busway for ready tapping to power and light loads.
—Careful attention to hazardous location installations.
—Thoroughly engineered protection against system faults.
—Adequate interrupting capacity in all devices which interrupt current flow—both control switching and protective equipment.
—Coordinated application of short circuit and overload protective devices to effectively isolate faulted sections of the system without interrupting service to other sections.
—Modern switchgear—totally-enclosed, dead-front for maximum safety; designed for easy maintenance.
—High power factor operation with excellent regulation of voltage at all levels in the plant.
—Use of high frequency (over 60 cps) electric energy for power applications and for maximum-efficiency fluorescent lighting.



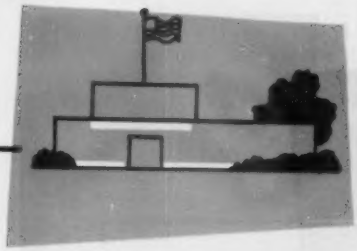
office buildings

Typical load densities for modern office buildings can run over 10 watts per square foot where electrical usage is at a maximum for light and power facilities. General area lighting may account for three or four watts per square foot; power loads, for four or more watts per square foot; and the balance of small machines and incidental loads, up to 2 watts per square foot.

—Primary supply to two or more unit substations widely spaced vertically within the building.
—Adequate interrupting capacities and coordinated protection.
—Distribution at 480/277 volts, 3-phase, 4-wire for power and general area fluorescent lighting.
—High frequency distribution system for high-level, high-efficiency fluorescent lighting.
—Busway risers.
—Aluminum conduit risers.
—Step-down local transformers for 120/208-volt, 3-phase, 4-wire supply to incandescent lighting and convenience receptacle circuits.
—Underfloor raceway systems for power, light, telephones and signals in large office areas with shifting loads or layouts.
—Effective alarms, signals and communication facilities—fire alarms, burglar alarms, watchmen's systems.
—Remote-control switching
—Carrier-frequency relay switching without control wires.

A utility power system is the most common type of supply to buildings and plants. Purchase of energy usually represents decided economy over the cost of private generation of electric energy within the building or plant. Of course, there are certain cases, such as paper and pulp mills, in which requirements for large amounts of process steam make possible the use of excess steam for economical generation of energy. In such cases, the generating plant may be operated independently of a utility supply to the building or in parallel with it.

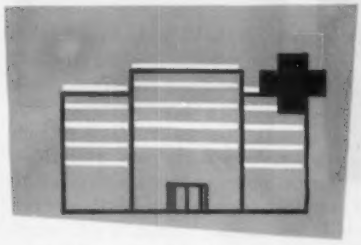
If the local generating plant operates independently, part of the total electrical load may be connected to it and part to the utility system. Use of a generating plant in parallel with a utility supply must be checked with the utility company engineers.



schools

Lighting loads for modern schools vary with the type and layout of buildings and the extent to which daylighting is utilized in classrooms. Typical load densities range from 2 to 5 watts per square foot, depending upon type of lighting—incandescent or fluorescent—and luminaires used. Power loads may include air conditioning, electric heating, ventilation, compressors and elevators.

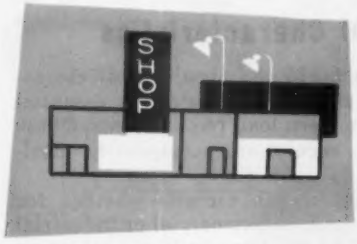
—Distribution at 4160 volts (or higher where direct utility supply requires) to two or more load centers in large-area, multi-building school layouts.
—Use of 480/277-volt distribution for power and lighting loads.
—Electric heating throughout school buildings for maximum comfort and effective climate control, minimizing maintenance and eliminating the hazards of combustible fuels.
—Modern, high-level lighting with maximum visual comfort.
—"Showcase" wiring and equipment application in laboratories and craft shops, providing integration in the teaching of electricity and its use.
—Modern gymnasium lighting, electric scoreboards, effective use of public address equipment.
—Engineered lighting and power facilities for auditoriums, including programmed, dimmer control of stage lighting and house lights.
—Intercom and paging systems.
—Closed-circuit television systems for instruction purposes.
—Clock and bell program system.
—Modern fire alarm system.
—Vandal alarm system to protect school against vandals and other intruders during closed hours.



hospitals

Typical electrical demand for modern hospital facilities can range up to 3,000 watts per bed where maximum use is made of electrical equipment.

—Use of load center distribution where possible.
—Careful provision for electrical supply continuity in case of failure of normal supply: two separate services, a special emergency service, an emergency standby power generator or standby dc supply for essential lighting and other essential facilities.
—Modern lighting throughout the hospital.
—Engineered application of modern signal and communication equipment: call and register systems, paging systems, intercom, closed circuit television, radio program distribution.
—Modern wiring of laboratory facilities, X-ray equipment.
—Careful compliance with all code requirements on wiring in operating rooms (ungrounded circuits and ground detector and alarm system) and in hazardous (anesthetizing) areas.



shopping centers

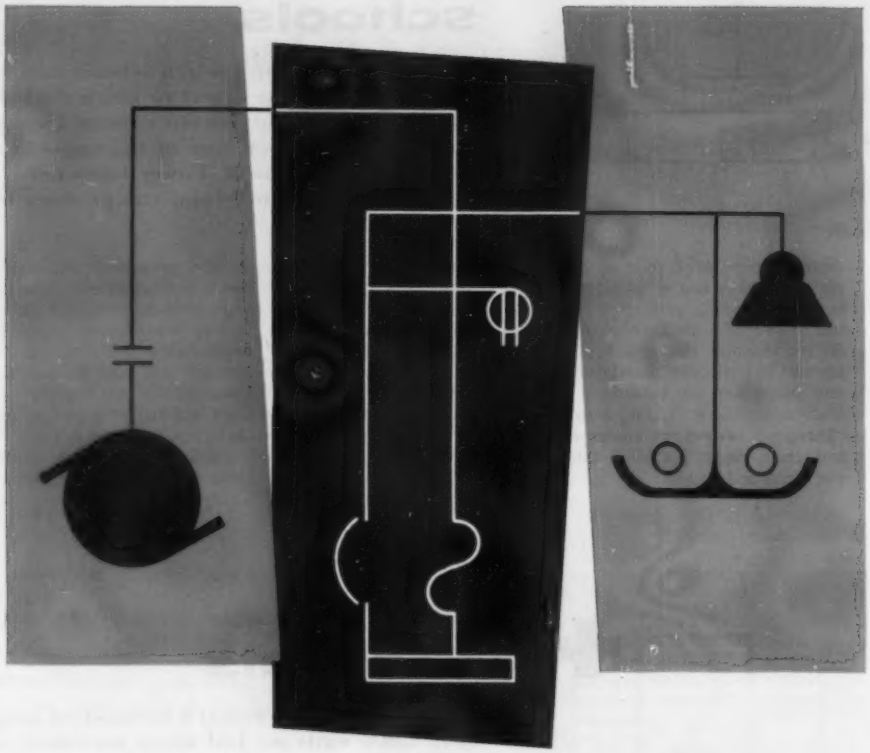
Lighting load densities vary widely for the different areas of shopping centers—from 3 to more than 10 watts per square foot. Actual figures depend upon the sizes and types of stores, the relative amounts of fluorescent and incandescent lighting, light used for decoration and the amount of outside lighting. Power load densities depend upon the facilities selected.

—Primary distribution to load center subs.
—Use of 480/277 volts among and within buildings.
—Use of contactors and split bus panelboards for time clock control of large blocks of sign, display and outdoor lighting.
—Modern store lighting.
—Music distribution, intercom and paging systems.
—Modern parking lot lighting: fluorescent and/or mercury-vapor luminaires.

If power is obtained from a utility line, the characteristics of the supply must be matched to the requirements of the building. Depending upon the voltage and capacity of the supply, one particular type of distribution is often best suited to carrying the electrical loads in the building.

Purchase of power at utilization voltages indicates certain types of distribution; higher voltage services and primary supplies also indicate their own types of distribution systems within the building. When several different supply voltages are available, each should be appraised in relation to the various distribution methods which might be used.

Consultation with the utility company about the relation between different services and interior distribution systems should precede any decisions.



LAY OUT THE . . .

BRANCH CIRCUITS

A BRANCH circuit is that part of a wiring system extending beyond the final automatic overload protective device of the circuit. In its simplest form, it consists of two wires which carry current at a particular voltage from the point of the protective device to an electrical utilization device or devices. Although the branch circuit represents the last step in the transfer of power from the service to utilization devices, it is the starting point for modern design procedure. First, the loads are circuited. Then the circuits are lumped on the feeders. Finally, the distribution system is powered.

Effective branch circuit design is essential in any system to assure full convenience in the use of electrical loads. It is also essential to efficient operation of load devices.

Although consideration of service and distribution methods is usually emphasized in electrical design work, design of modern circuit arrangements is extremely important to successful design of the overall electrical system. Thorough understanding of the theory and application of modern circuit techniques is assured by a breakdown and careful analysis of the factors involved.

General Characteristics

Design of branch circuits should take into account all of the general considerations essential to providing for modern load requirements. These include capacity, regulation, accessibility, flexibility and safety.

Each and every branch circuit—whether for power or lighting load, in commercial or industrial buildings—should be sized for its load, with spare capacity added where possible load growth is indicated, where necessary to reduce heating in continuously operating circuits and/or for voltage stability requirements. Design should also provide for economical addition of circuits to handle future loads. Regulation of each circuit must assure required power capacity at full utilization voltage at every circuit outlet.

Accessibility and flexibility are two important characteristics of effective branch circuiting. In commercial and industrial buildings, shifting of load devices as a result of tenant changes, rearranging of office layouts, changes in production schedules or relocation of production lines is common. Circuits in such areas must readily

accommodate these changes and must allow extensions.

Safety provisions in branch circuits are, of course, essential. Adherence to the provisions of the code will assure basic safety. In providing circuits for special or unusual utilization devices or for devices not covered in the code, the designer must call upon his own engineering skill and perception in providing effective control, grounding and protection for maximum safety.

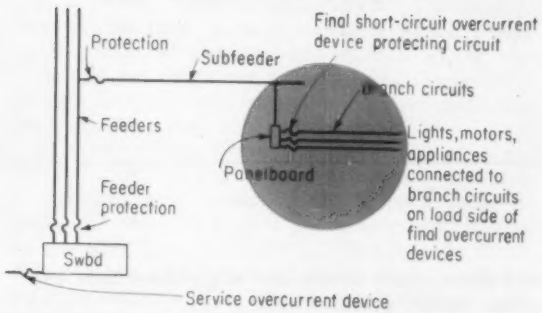
Modern Circuiting

In general, modern branch circuit design has developed from the trend toward high distribution voltages, incorporating the favorable economic and operating characteristics of load center layout. As a result, branch circuits are short runs from strategically located panelboards or transformer load centers instead of long circuits from a central distribution panelboard. The high voltage is delivered to the load center where it is stepped to utilization levels. Or in the one-voltage system, the feeder is carried to the approximate physical center of a load concentration area before it is subdivided into branch circuits. The use of load centers and resulting short branch circuits provides better-regulated voltage supplies to utilization devices and minimum circuit disturbances due to load changes.

Modern electrical systems use four basic types of branch circuit systems to serve utilization voltages to light and power outlets. These are derived from the common secondary distribution systems, as follows:

SINGLE-PHASE, 3-WIRE SYSTEM—This is a commonly used system in small apartment and commercial buildings. Both lighting and single-phase motor loads can be served, although the system is limited to use only where motor loads do not exceed 5 hp. Two-wire, 240-volt branch circuits can be used for power loads; 3-wire, 120/240-volt circuits for lighting outlets, split-wired duplex receptacles and some power devices such as electric ranges; and 2-wire, 120-volt circuits for lighting and receptacle outlets.

Definition of a Branch Circuit



BRANCH CIRCUIT—is that portion of a wiring system extending beyond the final overcurrent device which is approved for use as branch circuit protection. Thermal cutouts or motor overload devices are not branch circuit protection.
Rating of a branch circuit is determined by the rating or setting of the overcurrent device and not by the size of the conductors (which may be of higher capacity to reduce voltage drop and losses).

3-PHASE, 4-WIRE WYE SYSTEM—This is the most widely used 3-phase secondary distribution system. The most common use of this configuration is the 120/208-volt, 3-phase 4-wire system with the neutral grounded. With this system, a variety of circuits is available: 4-wire, 120/208-volt circuits; 3-wire, 120/208-volt circuits; 3-wire, 208-volt circuits; 2-wire, 208-volt circuits; and 2-wire, 120-volt circuits. Such a system can serve a combination of power and lighting loads and offers flexibility for circuit layout and application of utilization equipment.

Another 3-phase, 4-wire, wye connected system which has gained rapidly in acceptance and application is the 480/277-volt wye-connected system (also called 460/265-volt system, due to the voltage spread). Under certain conditions, this system offers more advantages and economy in commercial building applications than the 120/208-volt system. The system makes available three types of branch circuits: 480-volt, 3-phase for motor loads; 277-volt, single-phase for fluorescent or mercury vapor lighting; and 120-volt, 240-volt or 120/208-volt circuits from step-down transformers for receptacle circuits and miscellaneous loads.

Still another 3-phase, 4-wire system which has found some application utilizes a wye connection of 240-volt transformer secondaries to give 240/416 volts. Phase to grounded neutral is 240 volts for connection of 240-volt fluorescent ballasts for general lighting. Phase-to-phase the system provides 416 volts for motor loads. This system offers standard 10 to 1 transformation ratio for step-down from 4160/2400-volt wye or 2400-volt delta primaries (or from other primary voltages). It provides nearly the same copper and equipment economies as the 480/277-volt system, using standard 250-volt wall switches. And it is claimed that connection of 440-volt motors on 416 volts improves the power factor of the load.

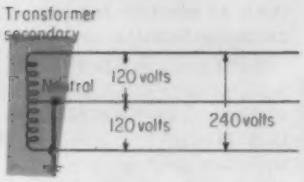
3-PHASE, 3-WIRE SYSTEM—This is the common delta-connected secondary system with phase-to-phase voltage of 240, 480 or 600 volts between each pair of phase conductors. This system is used where the motor load represents a large part of the total load. In some such systems, 3-phase, 3-wire circuits at 480 volts feed individual motor loads, with single- or 3-phase step-down transformers from 480 to 120 volts used to supply lighting and receptacle circuits.

3-PHASE, 4-WIRE DELTA SYSTEM—This is a variation on the 3-phase, 3-wire delta system above. One of the transformer secondary windings is center-tapped to derive a grounded conductor which is neutral to the 2-phase legs between which it is connected. Motors are supplied at 240 volts, with single-phase 120-volt branch circuits taken from the grounded, center-tapped conductor and its associated phases.

In some areas, electrical systems are supplied from two co-existing services—a 3-phase, 3-wire system for power loads and a separate 120/240-volt, single phase or 120/208-volt 3-phase grounded system for lighting and appliance loads.

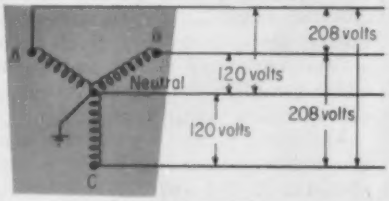
Common Branch Circuit Configurations

Single-phase, 3-wire



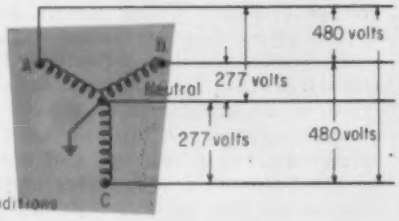
For single-phase light and power branch circuits.

3-phase, 4-wire wye (or star) with grounded neutral rated 120/208 volts



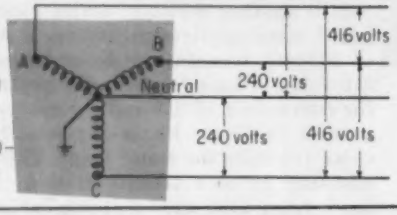
For 3-phase power circuits and single-phase light and power branch circuits.

3-phase, 4-wire wye (or star) with grounded neutral rated 480Y/277 or 460Y/265 depending upon voltage spread under local conditions



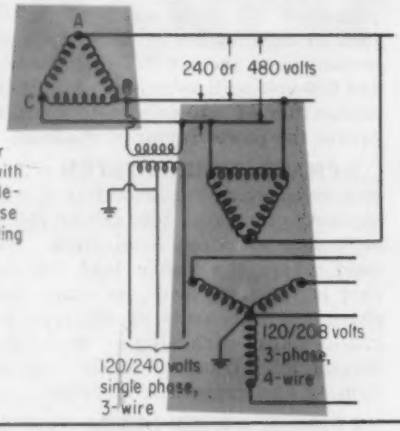
For 3-phase power circuits and lighting circuits using 277-volt ballasts. 120-volt lighting and receptacle loads are fed from this system through single-phase transformers rated 480/120-240 volts or 3-phase transformers rated 480/120-208 volts.

3-phase, 4-wire wye with grounded neutral rated 416Y/240 for 240-volt lighting and 440-volt power loads



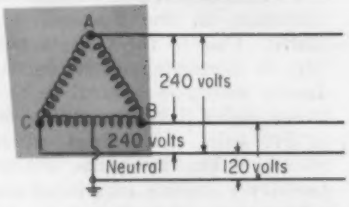
For 3-phase power circuits and lighting circuits using 240-volt ballasts. 120-volt lighting and receptacle loads are fed by transformers rated 240/120 volts connected single-phase or 3-phase.

3-phase, 3-wire delta for power loads with lighting circuits from transformers, or in conjunction with a separate single-phase or 3-phase service for lighting circuits



For 3-phase power circuits with lighting circuits at 120/240 volts derived from single-phase transformers balanced over the phases or lighting circuits at 120/208 volts derived from 3-phase 480-volt transformers.

3-phase, 4-wire delta with one phase center tapped and grounded



For 3-phase power circuits and single-phase light and power branch circuits.

NOTES:

1. Other system configurations are commonly used to supply branch circuits, but they are derived from the basic systems shown. Particular local conditions and/or requirements for load balance throughout an overall system frequently dictate the use of less common derivations of branch circuits. Such arrangements include 120/208 3-wire feeds to branch circuit panelboards, open-delta 3-phase supply to light and power branch circuits and other special transformer hookups supplying branch circuit loads.

2. Motor branch circuits may be served directly from high-voltage supplies.

General Purpose Circuits

Design of lighting layout for any commercial, institutional or industrial building includes determination of the required footcandle intensity of lighting, selection of the general type of lighting—incandescent, fluorescent, mercury vapor or some combination of these, number of lamps per luminaire, number of luminaires, types of luminaires, mounting details, wiring methods and other specifics covered in the section of this manual which describes lighting design. As a result of the lighting design for a particular area, a known value of required watts of circuit capacity is obtained. This value is used in determining the number of lighting circuits needed.

Number of Circuits

The number of branch circuits required to handle the general lighting load is based on the total load to be served, the layout of the lighting system and outlets, the amount of load to be placed on each circuit and the capacity of the circuits to be used. According to the code, the number of circuits shall be not less than that determined from the total computed load and the capacity of the circuits to be used. However, where a branch circuit load will be in operation for long periods—such as general illumination in large office areas, offices, schools, hospitals, industrial plants and the like—the total load on each branch circuit shall not exceed 80% of the rating of the circuit.

Although these code recommendations provide safety in the system, good design practice dictates even more limited loading of lighting branch circuits to assure minimum voltage drop, efficient operation and spare capacity for increases in load. Loading of circuits to half capacity is a widely used and highly recommended practice.

When fluorescent or mercury vapor lighting is used on branch circuits, the presence of the inductive effect of the ballast or transformer creates a power factor consideration. Determination of the load in such cases must be based on the total of the volt-ampere ratings of the units and not on the wattages of the lamps. The ballast nameplate current and voltage represent the total operating load of the lamp circuit.

In many cases, where the conditions of occupancy cannot be established prior to completion of the building and renting of its space, determination of required branch circuit capacity has to be made without a detailed lighting layout. Then, the number and types of circuits for general lighting may be based on a total wattage load obtained by using unit load densities in watts-per-square-foot. Typical modern unit loads for various buildings and specific areas are available. Such unit loads are based on achieving a given footcandle lighting intensity using equipment of average efficiency. Of course, known loads which exceed the loading indicated in these tables take precedence in design calculations.

Lighting Outlets

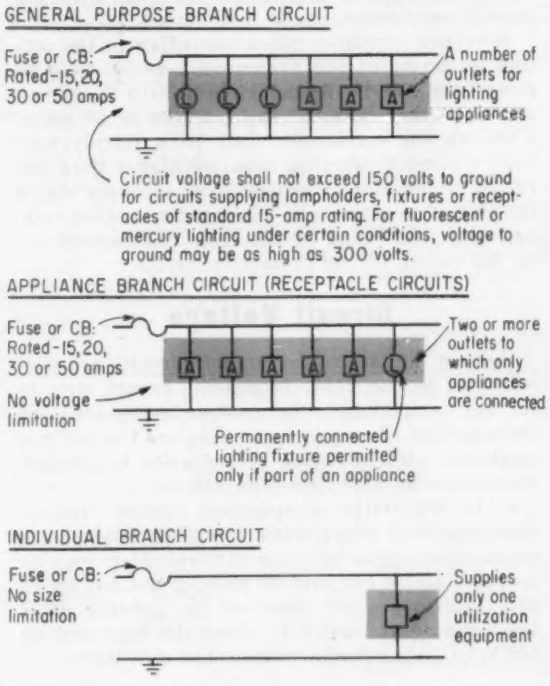
In commercial and institutional buildings, layout of the lighting outlets must conform to the general lighting plan, taking into consideration the required lighting result and the type and size of luminaires to be used. Location of lighting outlets will be determined accordingly.

In general, spacing between adjacent outlets should not exceed the floor-to-ceiling distance. In industrial buildings, location and spacing of outlets will vary with the work being done, the size and architectural features of the interior. Depending upon these factors, more or less of the lighting load will be general lighting rather than local lighting. Again, location of lighting outlets must correspond to the lighting plan.

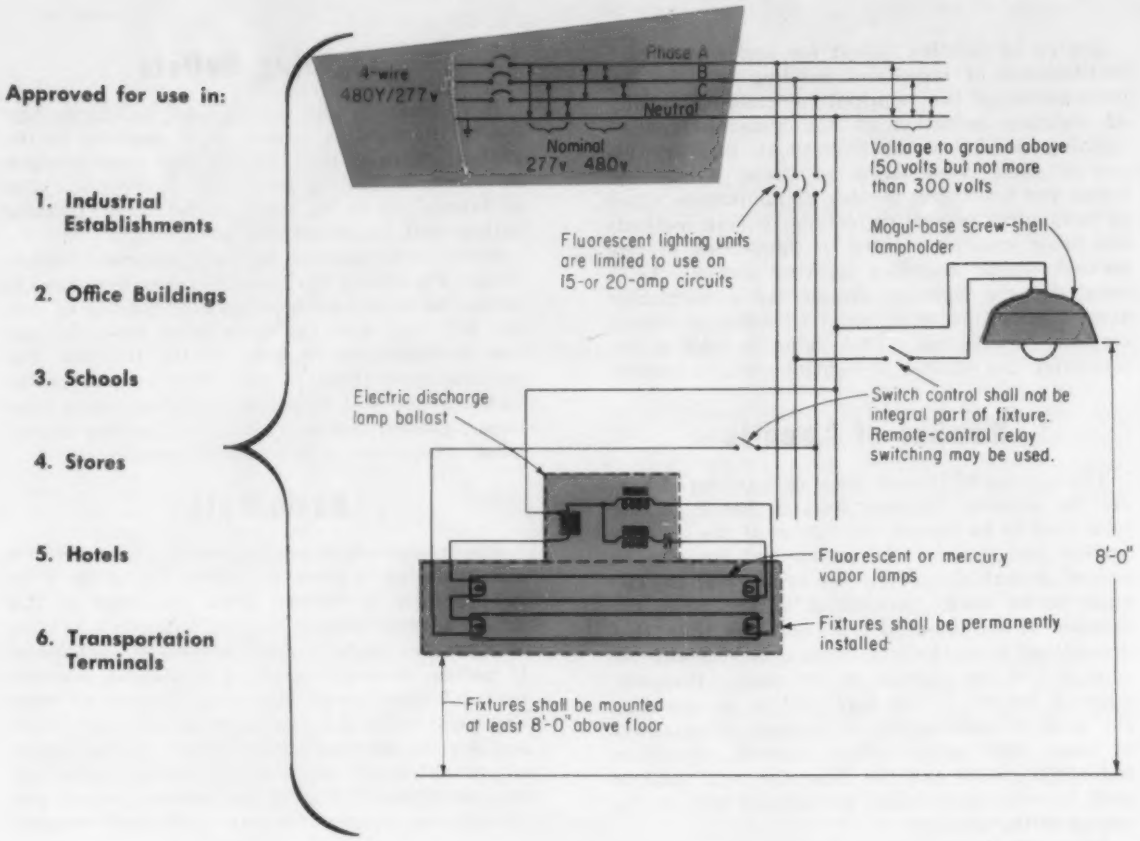
Basic Data

The framework of lighting and appliance branch circuit design is given in Article 210 of the code. As set forth in Section 2101, the scope of this article covers "branch circuits supplying lighting or appliance loads or combinations of such loads. If motors, or motor-operated appliances, are connected to any circuit supplying lighting or other appliance loads, the provisions of both this article and Article 430 shall apply. Article 430 shall apply if branch circuit supplies only motor loads." Although Article 210 gives the general overall provisions for branch circuits, additional require-

Types of Branch Circuits


GENERAL PURPOSE BRANCH CIRCUIT
Fuse or CB: Rated-15, 20, 30 or 50 amps
A number of outlets for lighting appliances
Circuit voltage shall not exceed 150 volts to ground for circuits supplying lampholders, fixtures or receptacles of standard 15-amp rating. For fluorescent or mercury lighting under certain conditions, voltage to ground may be as high as 300 volts.
APPLIANCE BRANCH CIRCUIT (RECEPTACLE CIRCUITS)
Fuse or CB: Rated-15, 20, 30 or 50 amps
No voltage limitation
Two or more outlets to which only appliances are connected
Permanently connected lighting fixture permitted only if part of an appliance
INDIVIDUAL BRANCH CIRCUIT
Fuse or CB: No size limitation
Supplies only one utilization equipment

Code Requirements for Lighting Circuits Operating at 277 Volts to Ground



ments and recommendations on branch circuits are given in other articles of the code covering specific equipment, loads and systems.

A branch circuit is rated according to the setting or rating of the overcurrent device used to protect the circuit. Branch circuits with more than one outlet may be rated at 15, 20, 30 or 50 amps. Although the conductors used in a circuit may have a current carrying capacity higher than the rating of the protective device, as in cases where the size of conductors is increased to reduce voltage drop, the rating of the circuit is determined by the rating of the protective device.

Circuit Voltage

Voltage limitations for branch circuits are presented in Section 2113. In general, branch circuits serving lampholders, fixtures or receptacles of the standard 15-amp or less rating are limited to a maximum voltage rating of 150 volts to ground. Exceptions to this rule are as follows:

a. In industrial occupancies, branch circuits supplying only mogul-base, screw-shell lampholders or other approved types of lampholders may be operated above 150 volts to ground, but not above 300 volts to ground, provided the lighting units are mounted at least 8 ft above the floor and do not have switch control within the unit itself.

b. In industrial, commercial and institutional occupancies, branch circuits serving only ballasts for mercury vapor or fluorescent lamps may be rated over 150 volts to ground, but not above 300 volts to ground, provided the ballasts are in permanently installed fixtures mounted at least 8 ft above the floor and the fixtures do not have manual switch control as an integral part of them.

c. Certain electric railway applications utilize higher circuit voltages.

d. Infrared lamp industrial heating appliances may be used on higher circuit voltages as allowed in Section 4237 of the code. The requirements for circuits serving electric heating devices are given in a later section of this manual.

"In dwelling occupancies, the voltage between conductors supplying lampholders of the screw-shell type, receptacles, or appliances shall not exceed 150 volts, except that the voltage between conductors supplying only (a) permanently connected appliances, or (b) portable appliances of more than 1,380 watts, or (c) portable motor-operated appliances of one-quarter horsepower or greater rating may exceed 150 volts."

Circuit Loading

Code limitations on the use of branch circuits with two or more outlets are as follows:

15- and 20-amp branch circuits may serve lighting units and/or appliances. The rating of any one portable appliance shall not exceed 80% of the branch circuit rating. Although fixed appliances may be connected to a circuit serving lighting units or portable appliances, provided the total rating of the fixed appliances does not exceed 50% of the circuit rating, good design provides separate circuits for individual fixed appliances. In commercial and industrial buildings, separate circuits should be provided for lighting and separate circuits for convenience receptacles.

30-amp branch circuits may serve fixed lighting units (with heavy-duty type lampholders) in other than dwelling occupancies or appliances in any occupany. Any individual portable appliance which draws more than 24 amps may not be connected to this type of circuit.

50-amp branch circuits may serve fixed lighting units (with heavy-duty type lampholders) in other than dwelling occupancies, fixed cooking appliances, fixed range and water heater, or infrared lamp industrial heating appliances.

It should be noted that the requirement of heavy-duty type lampholders for lighting units on 30- and 50-amp multi-outlet branch circuits excludes the use of fluorescent lighting on these circuits. Mercury vapor units with mogul holders may be used on these circuits provided tap conductor requirements are satisfied.

Requirements for branch circuits for grouped loads are covered in Section 2127 of the National Electrical Code. As indicated, branch circuits for lighting are limited to a maximum loading of 50 amps. Other limitations for general-purpose lighting and appliance circuits are presented in Article 210 of the code. Individual branch circuits may supply any loads. Excepting motors, this means that an individual piece of equipment may be connected to a branch circuit which has sufficient carrying capacity in its conductors, is protected against current in excess of the capacity of the conductors and in excess of 150% of the rating of an individual appliance and supplies only the single outlet for the load device.

Design of lighting and appliance branch circuits for dwelling type occupancies (hotels and apartment houses) should be based on a minimum provision of one 20-amp, 2-wire, 120-volt circuit for each 500 sq ft of floor area. The number of circuits determined in this way will handle general illumination and convenience receptacles spaced (so no point is more than 6 ft from a receptacle) along the floor line in any usable wall space of the living room, bedrooms, parlor, library, den, sun room and recreation room.

At least one 3-wire, 20-amp, 120/240- or 120/208-volt circuit shall be provided to serve the small appliance load in the kitchen, laundry, pantry, dining room and breakfast room of dwelling occupancies. This 3-wire circuit can be split-wired to convenience receptacle outlets in these areas and must have no other outlets. Of course, two 2-wire, 20-amp, 120-volt circuits are equivalent to the 3-wire circuit and could be used.

In apartment houses and hotel rooms, all receptacle outlets rated 15-amp or less (excepting air conditioning outlets and those outlets on the kitchen appliance circuits) are considered as outlets for general illumination and no additional branch circuit capacity has to be provided for such outlets. They are connected on the circuits designed to handle the general lighting load.

In other occupancies, circuit capacity must be provided for all receptacle outlets and outlets serving loads separate from general illumination.

Special Outlets

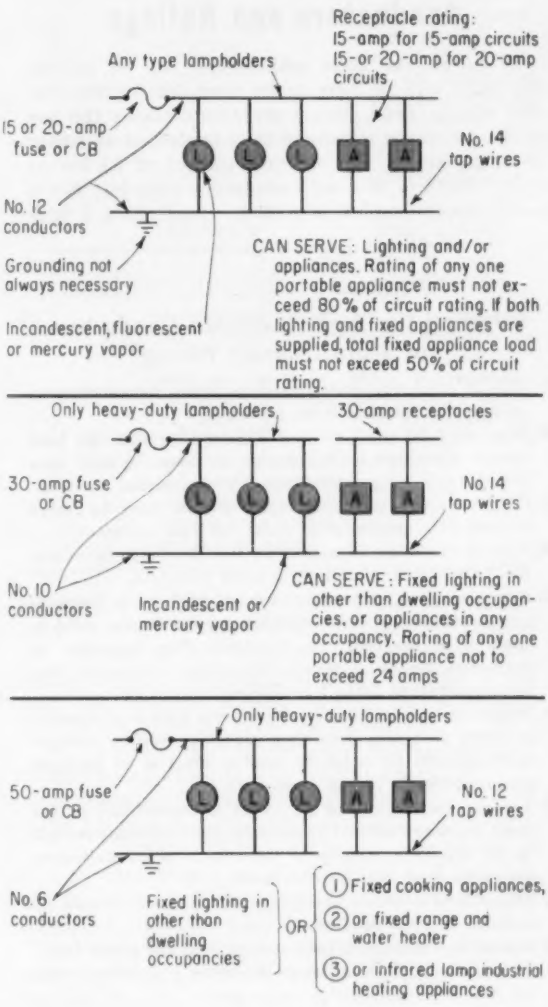
For lighting other than general lighting, and for appliances other than motor-operated, circuit capacity for each outlet must be provided as follows:

For each outlet supplying a specific appliance or load device, circuit capacity equal to the amp rating of the appliance or device must be provided.

For each outlet supplying a heavy-duty lampholder, 5 amps of circuit capacity must be allowed.

Loading of Multi-Outlet Circuits

(For Type R, RH-RW, RHW, RU, RUW, T and TW Wires in Raceway or Cable)


Receptacle rating:
15-amp for 15-amp circuits
15- or 20-amp for 20-amp circuits
Any type lampholders
15 or 20-amp fuse or CB
No. 14 tap wires
No. 12 conductors
Grounding not always necessary
Incandescent, fluorescent or mercury vapor
CAN SERVE: Lighting and/or appliances. Rating of any one portable appliance must not exceed 80% of circuit rating. If both lighting and fixed appliances are supplied, total fixed appliance load must not exceed 50% of circuit rating.
Only heavy-duty lampholders
30-amp receptacles
30-amp fuse or CB
No. 14 tap wires
No. 10 conductors
Incandescent or mercury vapor
CAN SERVE: Fixed lighting in other than dwelling occupancies, or appliances in any occupancy. Rating of any one portable appliance not to exceed 24 amps
Only heavy-duty lampholders
50-amp fuse or CB
No. 12 tap wires
No. 6 conductors
Fixed lighting in other than dwelling occupancies
OR
(1) Fixed cooking appliances,
(2) or fixed range and water heater
(3) or infrared lamp industrial heating appliances

For each other outlet, at least 1.5 amps must be allowed.

When a circuit supplies only motor-operated devices, the provisions of Article 430 of the code must be taken into consideration.

The above minimum load allowances for receptacle outlets and outlets for local lighting and appliances are modified for certain applications:

Table 29 in Chapter 10 of the code establishes the basis for computing the required branch circuit capacity for electric cooking appliances.

For show-window lighting, 200 watts of load can be allowed for each linear foot of show-window, measured along its base (instead of an allowance of the specified load per outlet).

A capacity of 1.5 amps must be allowed for each 5-ft or fraction thereof of each separate and continuous length of fixed multi-outlet assemblies. Each such length is considered as one outlet of 1.5-amp capacity. In those places where it is likely that a number of appliances will be used simultaneously, each 1 ft or fraction thereof is considered as an outlet and requires a load allowance of 1.5 amps. Allowances for multi-outlet assemblies do not apply to dwellings or guest rooms in hotels.

Conductors and Ratings

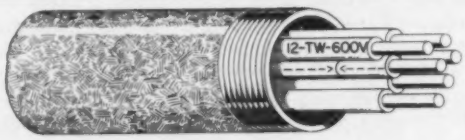
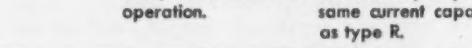
Although the code established No. 14 as the minimum size of wire to be used for branch circuit wiring, good design practice dictates the use of No. 12 as the minimum size, protected at either 15 or 20 amps. For electric ranges of 8¾ kw or more, No. 8 is the code minimum size, but No. 6 is the recommended size to be used. In a 3-wire

Selecting the Right Insulated Conductors for Branch Circuit Wiring

1. Size of conductors must provide sufficient current-carrying capacity for the load to be served.
2. Wires must be rated at least 25% greater than the load current when the load operates continuously over long periods, such as general lighting in commercial buildings.
3. Conductors for individual motor circuits must be rated at least 25% greater than motor full load current.
4. Type of insulation on conductors must be suited to operation at temperature of area in which it is used.
5. Where ambient temperature exceeds 86 F (room temperature maximum for which insulated conductors are rated in Table 1 of the NEC) the current-carrying capacities of conductors should be derated according to correction factors at bottom of Table 1 (or Tables 2, 1a or 2a).
6. Where more than three conductors are used in a raceway or cable, their current carrying capacities must be reduced to compensate for proximity heating effect in an enclosed group of closely placed conductors.
7. Type of insulation must be suited to application in the given moisture content. Advantages and limitations related to the dryness or wetness of the area in which conductors are to be used must be considered.
8. Where load additions are likely, spare capacity should be included in circuit conductors.
9. Size of conductors must keep voltage drop and power losses to a minimum. Modern design dictates a 1% voltage drop for branch circuits.

Common Branch Circuit Wires for Use in Raceway or Open Wiring

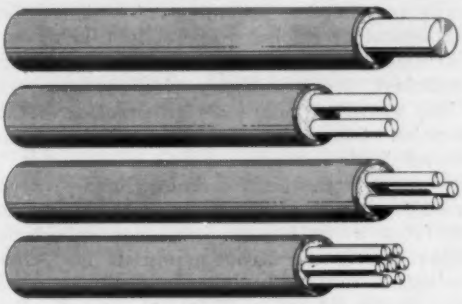
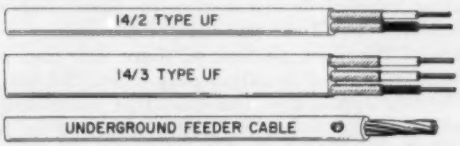
(Also for Use as Feeders)

Type	Construction	Application
R	Single rubber-insulated conductor with braided cotton covering, rated at 60 C maximum operating temperature.	For general use in dry locations.
RH	Similar to type R, but has heat-resistant rubber insulation, rated for 75 C operation.	For general use in dry locations. Has higher current-carrying capacity than type R.
RHH	Similar to type RH, but has heat-resistant rubber insulation rated for 90 C operation.	For general use in dry locations. Has same current-carrying capacity as type RH in sizes 14, 12 and 10. Has higher current rating for larger size conductors.
RW	Similar to type R, but has moisture-resistant rubber insulation, rated for 60 C operation.	For general use in dry or wet locations. Has same current capacity as type R.
RH-RW	Combines types RH and RW; has heat- and moisture-resistant rubber insulation rated 75 C in dry locations and 60 C in wet locations.	For general use in dry or wet locations. In dry locations, has current capacity of type RH; in wet locations, has current capacity of type RW.
RHW	Similar to RH-RW, rated for 75 C operation in all installations.	For general use in dry or wet locations. Has current capacity of type RH.
		
TW	Single plastic-insulated (polyvinylchloride) conductor; has high heat, moisture and corrosion resistance, rated for 60 C operation.	For general use in dry or wet locations. Has smaller cross-sectional area than type R, but is held to the same conduit occupancy. Has same current capacity as type R.
		
RU, RUH and RUW	Latex rubber equivalents of types R, RH and RW. Temperature ratings correspond.	Applications correspond to types R, RH and RW.

Common Cable Assemblies for Branch Circuit Wiring

(Also for Use as Feeders)

Type	Construction	Application
AC and ACT (National Electrical Code, Article 334)	Flexible metallic armored cables. Rubber (AC) or thermoplastic (ACT) insulated conductors in wound and interlocked steel armor covering, with bonding strip under armor.	For general interior wiring, except in moist areas or in block walls below grade.
ACV (NEC Art. 334)	Flexible metallic armored cable with varnished cambric insulated conductors.	For use exposed in dry locations in industrial areas.
ACL (NEC Art. 334)	Flexible metallic armored cable with lead-covered conductors.	For use where exposed to weather or moisture, for underground runs, for embedding in masonry or concrete or where exposed to oil, gasoline or other deteriorating agents.
NM (NEC Art. 336)	Non-metallic sheathed cable. Rubber or thermoplastic insulated conductors, with or without separate grounding conductor, covered by heavy paper wrapping and strong braid.	For interior wiring, exposed or concealed in dry locations. Must not be used exposed to corrosive fumes or vapors or embedded in concrete, masonry, fill or plaster.
NMC (NEC Art. 336)	Same as type NM cable except that it has a corrosion-resistant outer covering of non-fibrous material, such as neoprene or thermoplastic.	For interior wiring, n same ways as type NM, except that it may be embedded in plaster or run in chase if a 1/16 in. steel plate is provided for protection against nails.

Type	Construction	Application
		
MI (NEC Art. 330)	Mineral-insulated, metal-sheathed cable. Conductors insulated by highly compressed refractory mineral material and enclosed in liquid-tight and gas-tight flexible metallic tube sheathing.	For exposed or concealed use in dry or wet locations, under plastic, embedded in plaster finish on brick or other masonry, exposed to weather or moisture, underground runs, embedded in masonry, concrete or fill, in buildings in course of construction, or exposed to oil, gasoline or other conditions not having a deteriorating effect on the metal sheath.
		
UF (NEC Art. 339)	Underground feeder and branch circuit cable. Conductors may be plastic or rubber insulated, with an outer covering which is flame-retardant, moisture-resistant fungus-resistant, corrosion-resistant and suitable for direct burial in the earth.	For use underground, directly buried in the earth, as branch circuit cable. Multi-conductor type UF cable may be used as NMC cable, and may be used in wet locations.

single-phase branch circuit to an electric range, the neutral may be sized on the basis of 70% of the current-carrying capacity of the ungrounded conductors, although it may not be smaller than No. 10.

According to the code, the rating or setting of overcurrent device in any branch circuit shall not exceed the current-carrying capacity of the circuit conductor. If a circuit serves only one appliance rated at 10 amps or more, the rating of the overcurrent device must not exceed 150% of appliance rating.

Specific limitations are placed on outlet devices for branch circuits. Lampholders must not have a rating lower than the load to be served; and lampholders connected to circuits rated over 20 amps must be heavy-duty type. Again, this has been interpreted to exclude the use of fluorescent luminaires on 30-amp and 50-amp circuits (unless the luminaires are individually protected). Receptacles must have ratings at least equal to the load. On circuits having two or more outlets, receptacles shall be rated as follows:

On 15-amp circuits—not over 15-amp rating.
On 20-amp circuits—15- or 20-amp rating.
On 30-amp circuits—30-amp rating.
On 50-amp circuits—50-amp rating.

The code notes the possibility of using both ac and dc energy in a single building and requires the use of attachment plug caps which are not interchangeable between ac and dc receptacles.

All of the foregoing constitutes minimum standards for branch circuits. Actual design of circuiting begins with these requirements.

Design Approach

Design standards for lighting and appliance circuits are aimed at providing convenience, flexibility, operating efficiency and reliability in using the available energy. To assure all the advantages of sufficient circuit capacity plus spare capacity for load growth, modern design practice dictates separation of loads into known, approximated and unknown loads.

General illumination is a known load—whether derived from a detailed lighting layout, or developed from a watts-per-square-foot calculation. Number, rating and layout of outlets for general illumination can easily and accurately be apportioned among a number of branch circuits. Such circuits can be carefully loaded with due regard to voltage drop, operating cycle, possible increase in lighting level in the future and required control.

Depending upon the type of occupancy and how the interior is to be laid out from a work standpoint, outlets for local and/or special lighting units represent approximated loads. Such outlets are included in the overall lighting design, either as fixed unit loads or estimated plug-in loads. Outlets—either lampholders or plug receptacles—for such lighting units may be connected to general lighting circuits, provided with separate circuiting or included in circuits allowed for plug receptacles.

Design of branch circuits for plug receptacles requires careful determination of particular requirements. The type and size of occupancy and nature of the work performed there will indicate the best manner of handling plug-connected loads. For known appliances, individual or multi-outlet branch circuits should be used, depending on the size of the load represented.

Automatic appliances should always be provided with separate circuits to isolate such appliances from the effects of faults or other disturbances in other load devices. Fans or heaters might be individually fed by branch circuits, grouped on their own branch circuits or connected to receptacles on general lighting circuits.

Of course, the number of plug-in appliances in a particular area will greatly affect the circuiting. In general, plug-in devices should be supplied from receptacles on circuits other than general lighting circuits. In this way, the relative loading of circuits can be kept under better control, and spare capacity can be more realistically allowed.

Code Definitions of "Location"

Dry Location: A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

Damp Location: A location subject to a moderate degree of moisture, such as some basements, some barns, some cold storage warehouses, and the like.

Wet location: A location subject to saturation with water or other liquids, such as—

1. locations exposed to weather,
2. locations like garage washrooms,
3. underground installations,
4. installations in concrete slabs or masonry in direct contact with the earth.

Circuit Load Calculations

Branch Circuits—Lighting and Appliance

Two-wire circuits at any power factor:

$$\text{Line current} = \frac{\text{volt-amperes of connected load (or watts at unity pf)}}{\text{line voltage}}$$

Three-wire circuits at any power factor:

Single-phase—Apply same formula as for 2-wire branch circuit, considering each line to neutral separately. Use line-to-neutral voltage; result gives current in line conductors.

Three-phase: Line current =

$$\frac{\text{volt-amperes of balanced 3-phase load}}{\text{line voltage} \times 1.732}$$

Electric Range Circuits

Two-wire circuits:

$$\text{Line current} = \frac{\text{total connected load (watts)}}{\text{line voltage}}$$

Three-wire circuits:

$$\text{Line current} = \frac{\text{total connected load (watts)}}{\text{voltage between outside wires}}$$

NOTE: The total connected load in the above formulas is the rated watts of range or other cooking appliances up to 1¾ kw. For units rated higher than 1¾ kw, Table 29 Chapter 10 of the NE Code should be used to determine the maximum demand load. The demand load is then used above instead of the connected load in sizing the current-carrying capacity of the circuit conductors. Conductors smaller than No. 8 must not be used for circuits to ranges rated 8¾ kw or over, but the neutral in a 3-wire circuit to such a range need have only 70% of the carrying capacity of the ungrounded conductors.

Circuit Standards

Summarizing the recommendations made in foregoing discussion of code sections, the following are important standards for modern branch circuit design. Of course, in many cases, practical considerations such as size of area or type of load devices will require deviation from the letter of these standards. General standards for the majority of applications, however, are as follows:

- Separate branch circuits should be provided for general lighting, for automatic appliances, for fixed appliances and for plug receptacles. Generally, each automatic or fixed appliance should be served by an individual circuit.
- Branch circuits with more than one outlet supplying general lighting should not be loaded in excess of 50% of their carrying capacity.
- Branch circuits with more than one outlet supplying plug receptacles should not be loaded in excess of 50% of their carrying capacity.
- Branch circuits with more than one outlet supplying heavy-duty lampholders should not be loaded in excess of 50% of their carrying capacity.

● Individual branch circuits should have spare capacity 20% in excess of their loads.

● At least one spare circuit should be allowed for each five circuits in use.

● The smallest wire size used in branch circuiting should be No. 12.

● Size of wire to be used in a branch circuit home run should be at least one size larger than that computed from the loading when the distance from the overcurrent protective device to the first outlet is over 50 ft.

● When the distance from the overcurrent protective device to the first plug outlet on a receptacle circuit is over 100 ft, the size of the circuit home run should not be less than No. 10 and may be larger depending upon the rating of the particular circuit, the actual distance, voltage drop and the load conditions.

● Home runs on lighting circuits should be limited to a maximum of 100 ft, unless the load on the circuit is so small that voltage drop between the overcurrent protective device and any outlet is under 1%. Careful layout of panelboard locations and use of sufficient number of panelboards will avoid this problem of long home runs.

Plug Receptacles

The number of plug outlets connected on a single circuit should be related to the amount of load likely to be connected to any one receptacle in a particular occupancy. When plug-connected loads are known, determination of the proper number of plug outlets is relatively easy. And the number of circuits required in such cases follows directly from the loads and circuit capacities.

When plug-connected loads are not known, the type of occupancy will indicate the possible appliances to be provided for. If the possible appliances are relatively heavy-current devices, two or three outlets per circuit might be the maximum number to allow efficient and convenient use of the circuits. If the possible appliances are low-current devices, up to ten plug outlets may be connected on the circuit without the likelihood of overload.

Of course, the possible number of appliances to be used in any area will also affect the design of receptacle circuits. When special requirements for receptacle circuits arise after tenants move into an area, the spare circuits in the panelboard and extra capacity in the existing system of raceways or underfloor system will offer solution to the need.

Number of plug outlets required for different occupancies is not a matter of easy or standard calculation. The following are suggestions for receptacle layouts in various areas:

1. In office buildings, growing use of business machines dictates heavier load allowances for plug outlets. In separate offices of less than 400 sq ft area, at least one plug outlet should be allowed for each 20 linear feet of wall space. In each office area of over 400 sq ft, five plug outlets should be allowed for the first 400 sq ft of floor area and two plug outlets for each additional 400 sq ft of floor area or fraction thereof. The number of outlets obtained in this way should be evenly distributed throughout the area.

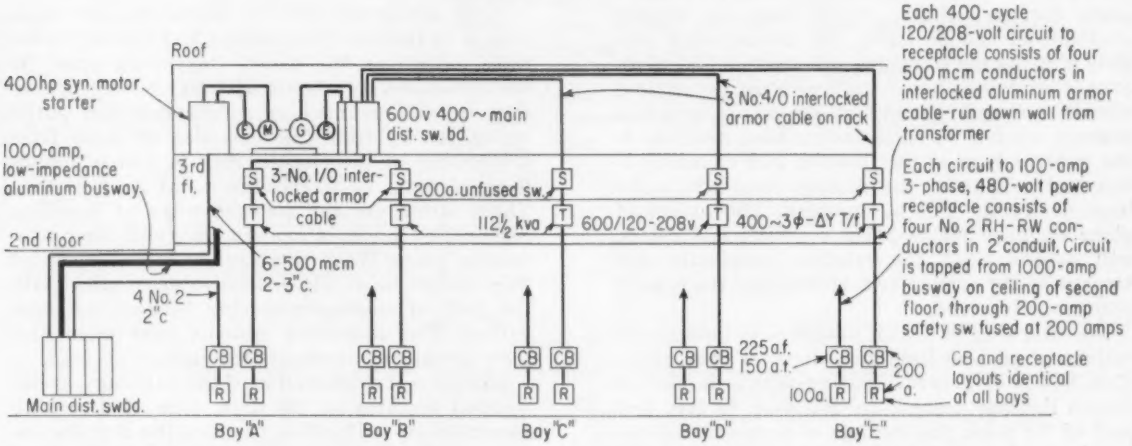
2. In schoolrooms, common practice has been to provide at least one plug outlet on the front wall of the room and one on the rear wall.

3. In stores, at least one plug outlet should be provided for each 400 sq ft of floor area or major fraction thereof.

4. Plug outlets for industrial areas should be provided on the basis of particular conditions in each case.

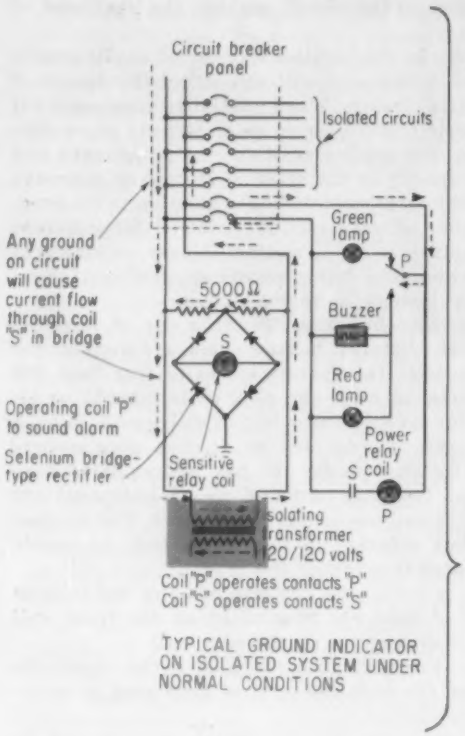
Branch circuit design must include provision for control of the circuits. Circuits supplying only plug outlets need not be controlled locally, although such control is often desirable and recommended. Control of branch circuits at the panel-

Distribution for Plug Outlets


Roof
400hp syn. motor starter
1000-amp, low-impedance aluminum busway
3rd fl.
2nd floor
600v 400~main dist. sw. bd.
3 No.4/0 interlocked armor cable on rack
3-No. 1/0 interlocked armor cable
200a. unfused sw.
112½ kva
600/120-208v
400~3ϕ-ΔY T/f
6-500 mcm 2-3"c.
4 No. 2 2"c
225 a.f. 150 a.f.
200 a.
100a.
Main dist. swbd.
Bay "A"
Bay "B"
Bay "C"
Bay "D"
Bay "E"
Each 400-cycle 120/208-volt circuit to receptacle consists of four 500 mcm conductors in interlocked aluminum armor cable-run down wall from transformer
Each circuit to 100-amp 3-phase, 480-volt power receptacle consists of four No. 2 RH-RW conductors in 2" conduit. Circuit is tapped from 1000-amp busway on ceiling of second floor, through 200-amp safety sw. fused at 200 amps
CB and receptacle layouts identical at all bays

RECEPTACLE CIRCUITS in modern jet airplane hangar supply 60-cycle and 400-cycle energy for servicing of planes in the hangar bays. The circuits are protected at their origins and at the receptacles. Aluminum interlocked armor cable was selected for the 400-cycle circuits because of the non-magnetic character of the armor. This minimizes self-induction and consequent voltage drop. The armored cable was selected over busway with aluminum enclosure and conductors in aluminum conduit because of its unusual flexibility for this application.

Code Requirements for Ungrounded Circuits in Hospital Operating Rooms, Delivery Rooms and Rooms or Other Areas Used for Administering Combustible Anesthetics



CIRCUITS WITHIN ANESTHETIZING LOCATIONS

- shall be ungrounded and supplied from an ungrounded distribution system which is isolated from other distribution systems by means of one or more transformers having no electrical connection between primary and secondary windings.
- shall be controlled by a switch having a disconnecting pole in each conductor.
- shall operate at not more than 300 volts between conductors.
- shall have an approved overcurrent device of proper rating in each conductor.
- shall be provided with an approved ground contact indicator.

CIRCUITS SUPPLYING ISOLATING TRANSFORMERS

- shall operate at not more than 300 volts between conductors.
- shall be provided with proper overcurrent protection.

ISOLATING TRANSFORMERS AND OVERCURRENT DEVICES

- shall be installed in non-hazardous locations.

GROUND CONTACT INDICATOR IS REQUIRED, AND—

- shall respond if any conductor of the system becomes grounded.
- shall limit the leakage current to 2 ma should any conductor become grounded.
- shall include a green signal lamp conspicuously visible to personnel in the anesthetizing location which shall remain lighted as long as no ground exists.
- shall include, adjacent to the green lamp, a red signal lamp and an audible alarm signal which will be energized should any ground occur on the system.
- shall not be installed within a hazardous area.
- should be tested at least weekly for proper operation by successively grounding each conductor of the system through a suitable meter or resistor.

board is a common and satisfactory practice in many occupancies. But in most occupancies, local control should be provided for convenience and economy of operation. Switching may be done at the circuit voltage or by low-voltage relays.

Layout on Plans

Actual design procedure for lighting and appliance branch circuits involves working on a set of plans for the building. Such plans are usually available or can be made. The design work consists of using the foregoing information and whatever other data is known in laying out the outlets, circuit runs and control legs. Of course, this step depends upon a decision having been made as to the general type of distribution and characteristics and voltage of the feeders from which the branch circuits will be supplied. The extent of plans required for notating the electrical design will depend upon the relative complexity and amount of the particular circuitry and the type of occupancy involved.

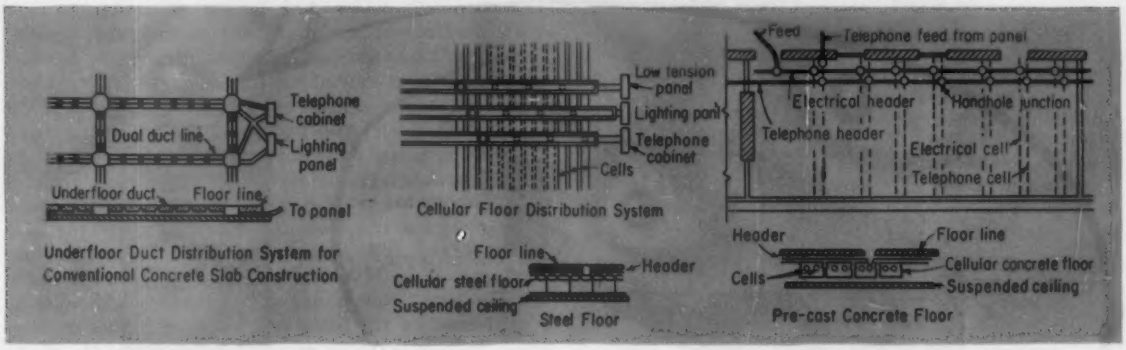
The first step in circuit design is to indicate locations of general lighting outlets on floor plans. This layout of general lighting outlets is part of overall lighting design. As follow-up to this first part of the work, the wattage of each outlet is determined, the total load is determined and the number of circuits is selected. Then the local or special lighting outlets are indicated. These include: corridor lights, exit lights, entrance lights, washroom lights, closet lights, stockroom lights, emergency lights and/or other known lighting outlet requirements.

In the design of many commercial and industrial buildings, the specifics of lighting requirements may not be known until after it is known what type of work will be performed and tenants decide upon their working layout. In such cases, provision of sufficient capacity and circuits in the panelboard is the initial limit of circuit design work.

After laying out lighting outlets, the next usual step is to indicate convenience and special receptacle outlets on the plans. Depending upon the occupancy, receptacle circuits may be run in conduit to wall-mounted or column-mounted outlet boxes, fed up from the floor slab or down from the ceiling, or the circuits may be run in underfloor raceway or a cellular metal floor system. These latter are the common ways of handling receptacle circuits in modern office and other commercial areas. When receptacles are wall-mounted they should be evenly spaced in accordance with the limit of maximum spacing between adjacent outlets. The underfloor systems offer more uniform layout of receptacles throughout an area.

The general construction of the building—architectural features of the area, type of floor slab construction—will affect the way the circuits are run and the locations of outlets. On the basis of careful selection of the number and types of convenience receptacles for general loads and special receptacles for known loads, layout of the outlets must conform to any known locations of load

Three Types of Underfloor Raceway Systems for Branch Circuits



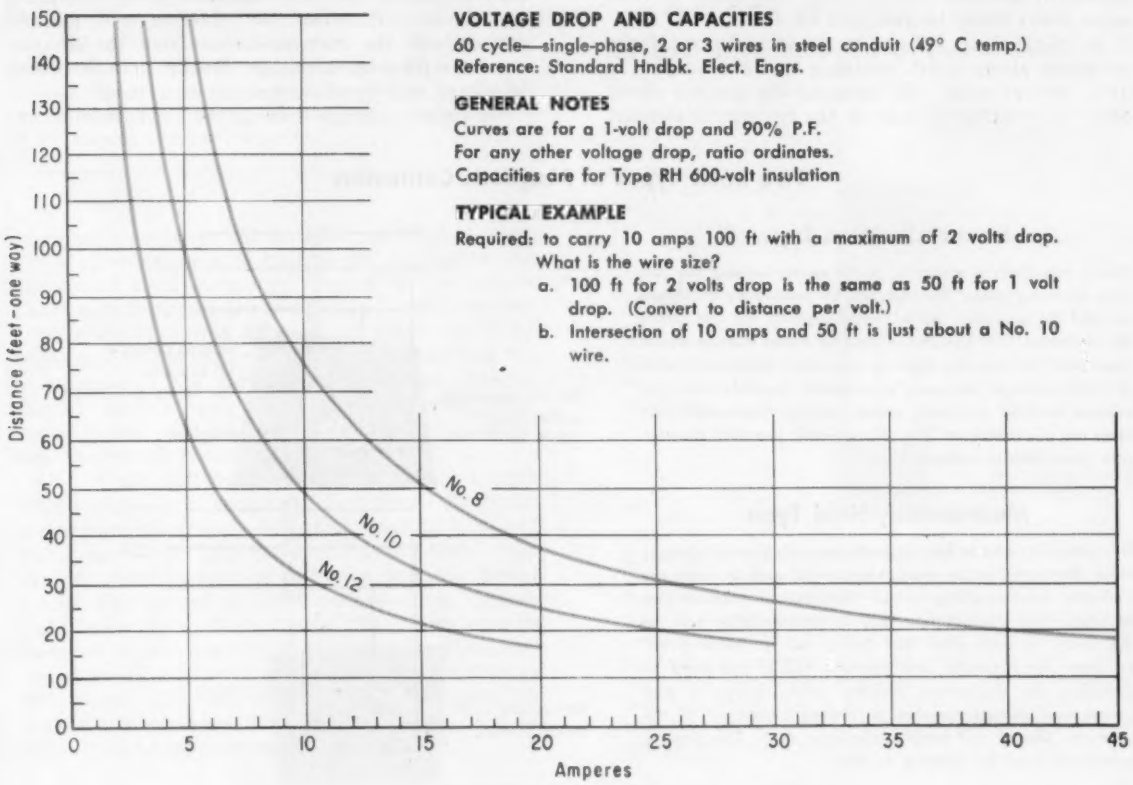
devices, allowing even spacing of convenience outlets for general (unknown) plug-connected loads. Special attention should be given to receptacle circuits serving individual loads. Fan and clock outlets should also be determined on the basis of special analysis.

From the indications of outlets and corresponding wattages on the plans, the number of circuits is the next determination. As discussed previously, circuiting to these outlets may be done in many ways. Combinations of general lighting, local lighting and appliance loads or motor loads can be connected to a single circuit if particular conditions require. But separate circuiting of load types, wherever possible, is recommended practice. Makeup and loading of circuits should follow previous recommendations.

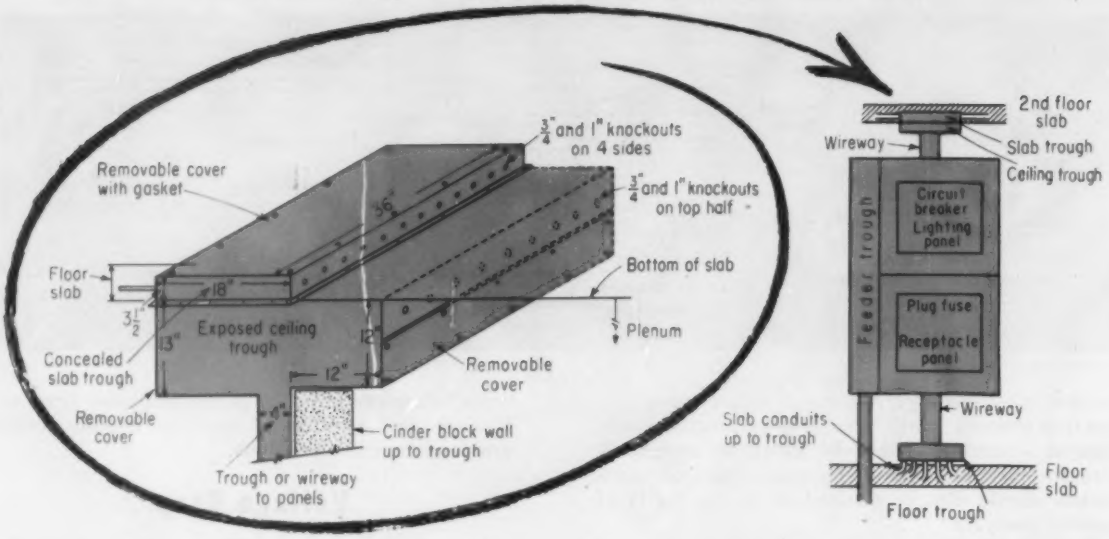
Voltage Drop

In laying out circuits, the loading and lengths of home runs and runs between outlets must be related to voltage drop and the need for spare capacity in the circuit for possible future increases in load. Each lamp, appliance or other utilization device on the circuit was designed for best performance at a particular operating voltage. Although such devices will operate at voltages

Branch Circuit Voltage Drop and Current Capacities for 600-Volt, Type RH Conductors



Special Raceway Application



AUXILIARY GUTTERS and various configurations of metal troughs can often simplify design of panelboard distribution centers for branch circuits. Typical example at left shows concealed trough set in floor slab to provide termination for branch circuit conduits run in slab. This open-bottom trough was mounted on deck forms during slab construction. The bottom section of trough was added after forms were removed. Connections between troughs and panel enclosure are made by steel raceway with interior partitions to group circuit conductors for each panel. Wireways are designed to conform to NEC 3624, including cross-sectional fill and number of conductors in each section. This method was dictated by confined space at electrical centers under stairways. It eliminated stubbing down conduit home runs with the inherent nippling-out to panels. Crossovers of home run conduits in the slab were also eliminated. At right, method is adapted to special branch circuit center which separates lighting and receptacle circuits. Feeder trough keeps these conductors out of the panel gutters. Floor trough for slab conduits to receptacles is raised to keep moisture out of conduits.

on either side of the design value, there will be generally adverse effects due to operation at voltages lower than the specified value.

A 1% drop in voltage to an incandescent lamp produces about a 3% decrease in light output; a 10% voltage drop will decrease the output about 30%. In heating devices of the resistance element type, voltage drop has a similar effect on heat output. In motor operated appliances, low voltage to the device will affect the starting and pull-out torque, and the current drawn from the line increases with drop in voltage. Heat rise in the motor windings will be above normal as a result.

Of course, voltage drop in the conductors is due

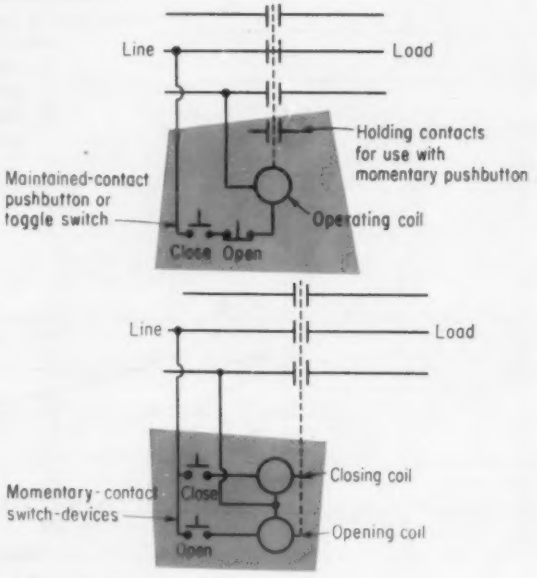
Two Basic Types of Magnetic Contactors

Electrically-Held Type

This is essentially a magnetic motor starter without the running overload relays. The coil must be continually energized to hold the contactor closed. De-energizing the coil opens the contactor. This type unit is used for motor starting equipment and for switching lighting and other loads on circuits of stable voltage. Because the contactor depends upon coil voltage to hold it closed, severe voltage fluctuations can drop out the contactor. This characteristic provides low-voltage protection or release.

Mechanically-Held Type

This type of contactor has magnetic operating mechanisms to close the contactor by energizing a coil and to open the contactor by energizing a coil. Various coil hookups can be used. The contact assembly is mechanically held in the closed position after the closing coil is de-energized. To open the contactor, the opening coil is energized to overcome the mechanical holding force. Energy is consumed only during opening or closing movement of the contacts. Closed unit holds on voltage dips. This type is commonly used for lighting control.



to resistance of the conductors plus, in ac circuits, reactance. And the heat developed by the dissipation of power in the wiring, which itself costs money, deteriorates the conductor insulation. To prevent poor equipment performance and the other bad effects, branch circuit conductors must be sized to keep voltage drop in the circuit under 1%.

Although the recommended 50% loading of circuits offers substantial protection against excessive voltage drop, size of conductors for long runs should always be carefully determined to assure that the spare capacity provision has not been removed by the limit of voltage drop. For this reason, when the design intent is to use 50% loading to provide spare capacity in the circuit, conductors used in long runs should be sized for voltage drop on the basis of the maximum possible loading.

Control

Local switches for load devices and receptacles should be carefully indicated on the plans. The particular requirements for local switching will also have an effect on the number of circuits required.

Switching at the panelboard requires a separate circuit for each block of equipment to be switched separately. Such factors as distance from panelboard to lighting fixtures, partitioning of the area of lighting coverage fed from the panelboard, need for 3- or 4-way switch control will determine the amount of local switching, the amount of panelboard switching and the number of circuits needed.

Selection of switch locations on plans should be based on careful analysis of the conditions and requirements of the particular installation. Special control devices such as photoelectric cells, time switches and relays should be carefully designed into the overall branch circuit layout.

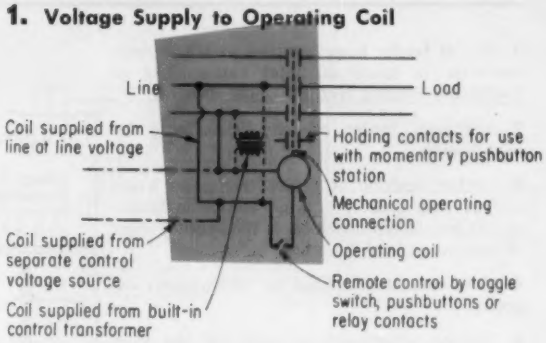
One of the most popular types of modern branch circuit control is contactor switching. Magnetic contactors—electrically-held and mechanically-held types, depending upon the stability of control voltage and such factors as coil hum and coil power drain—may be used in individual enclosures for control of circuits or load devices. They may also be mounted in split-bus type panelboards for block control of a section of the panel bus supplying a number of circuits. The operating coil of a contactor (or remote control switch, as it is also known) may be either manually or automatically switched.

Type AC General Use Snap Switch

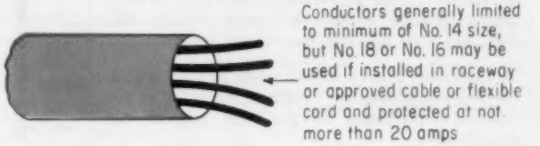
In the Electrical Construction Materials List published by the Underwriters' Laboratories and listing all materials which have been found by the Laboratories to be suitable for use under the National Electrical Code, the following definition appears in the section on snap switches: "AC general use snap switches (flush and surface types) are tested for controlling resistive, inductive (including fluorescent lamp) and tungsten-filament lamp loads (at 120 volts) up to the full current rating of the switch, and for motor loads up to 80% of the ampere rating of the switch."

Design Elements of Contactor Circuits

1. Voltage Supply to Operating Coil


Line
Load
Coil supplied from line at line voltage
Holding contacts for use with momentary pushbutton station
Mechanical operating connection
Operating coil
Coil supplied from separate control voltage source
Remote control by toggle switch, pushbuttons or relay contacts
Coil supplied from built-in control transformer

2. Requirements for Control Conductors


Conductors generally limited to minimum of No. 14 size, but No. 18 or No. 16 may be used if installed in raceway or approved cable or flexible cord and protected at not more than 20 amps

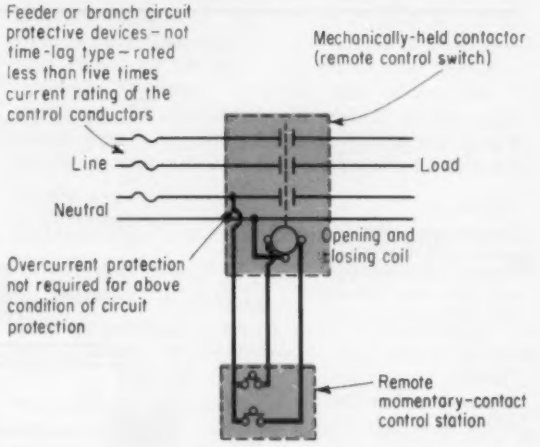
1 Number of conductors limited in raceway in accordance with code Tables 4 and 9, Chapter 10.

2 Control conductors do not have to be de-rated according to number in raceway.

3 When control conductors are run in raceway with power and light conductors, all conductors must be de-rated in accordance with note 4 following Tables 1 and 2, Chapter 10, NEC—determining the de-rating factor on the basis of the number of power and light conductors only.

4 Conductors for two or more remote control circuits may be run in the same raceway—ac and/or dc circuits—if all conductors are insulated for the maximum voltage of any conductor in the raceway.

3. Overcurrent Protection of Control Circuit


Feeder or branch circuit protective devices – not time-lag type – rated less than five times current rating of the control conductors
Mechanically-held contactor (remote control switch)
Line
Load
Neutral
Opening and closing coil
Overcurrent protection not required for above condition of circuit protection
Remote momentary-contact control station

Protection of contactor remote-control conductors must follow Section 2403-g. As shown above, separate protection of the control conductors is not required under the given conditions. If the stated requirements were not satisfied, a fuse or circuit breaker would have to be inserted in the control circuit tap from the operating coil to the hot line conductor. And if the control circuit were energized from two hot conductors, both taps would have to be protected. Control circuit could have been derived from a separate source instead of the line side of the remote control switch.

Major Considerations in Circuit Design for Contactor Control

1. Size of feeder from bus plug switch to main contactor is based on total volt-amperes of fluorescent lighting load at 100% demand.

2. Additional feeder capacity is included for load growth.

3. Further upsizing of feeder conductors keeps voltage drop under 1% from service to branch circuit panelboard and reduces the heating effect of continuous load operation.

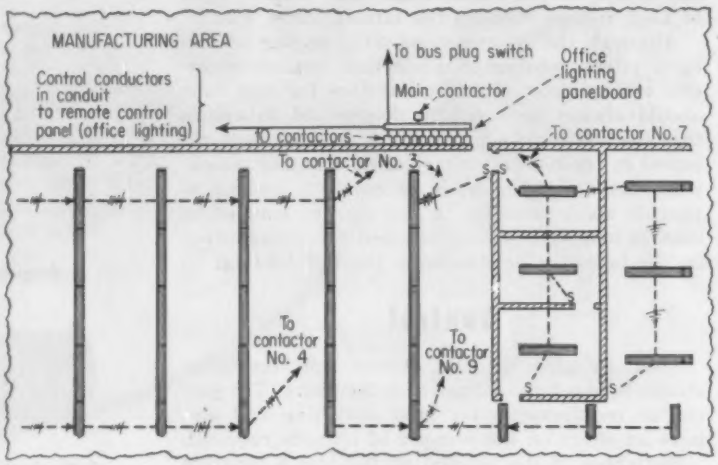
4. Main contactor is sized to match feeder capacity.

5. Lighting panelboard is rated for the total feeder capacity.

6. Branch circuit protection consists of 20-amp, 3-pole CB's for multi-wire branch circuits (NEC Sec. 2111) to 277-volt fluorescent ballast.

7. Individual branch circuit contactors are 3-pole, 30-amp remote-control switches connected in the lighting panelboard on the load side of the branch CB's.

8. Each branch circuit is loaded to 50% of its capacity. (80% loading is the NEC maximum for continuously operating circuits).



OFFICE LIGHTING of continuous row fluorescent luminaires is circuited from a remote control contactor panelboard which is outside the office area, on the wall of the adjoining manufacturing area. The special panelboard is fed by conductors tapped from a busway plug switch, as indicated. The panel is equipped with a main contactor which switches the supply to the panel mains. Each branch circuit consists of a branch CB and a remote control contactor. All control circuits are carried in conduits to a control panel on the wall at one end of the office area.

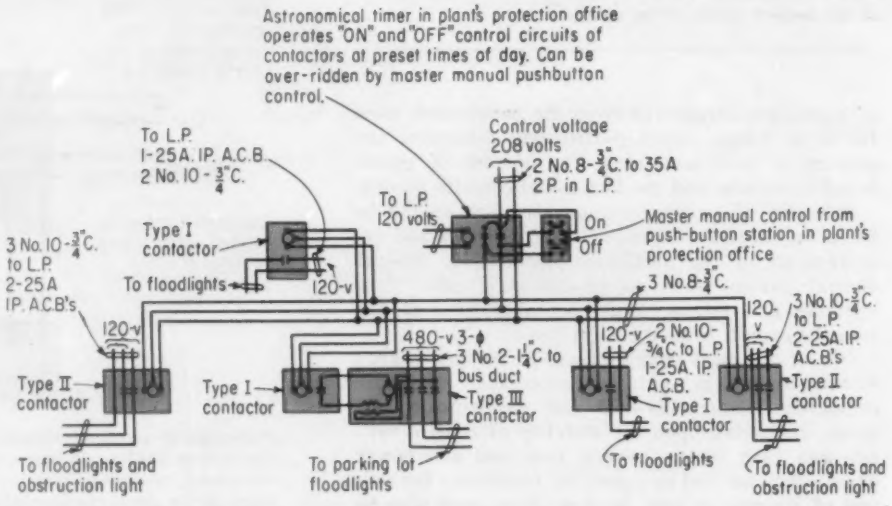
Central Control System for Operation of Widespread Contactors Switching Lighting Branch Circuits

TYPES OF CONTACTORS USED IN THIS SYSTEM

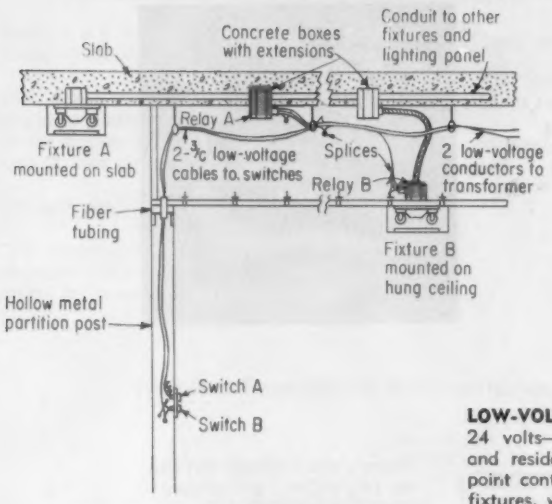
Type I-
Electrically-operated, mechanically-held, 60-amp 250-volt ac contactor, with 1 NO contact and with 208-volt operating coil

Type II-
The same as Type I but with 2 NO contacts

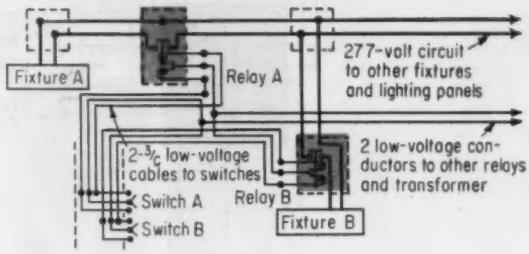
Type III-
Electrically-operated, electrically-held, NEMA Size 4, 600-volt contactor, with 480/120-volt control transformer and 120-volt operating coil.


Astronomical timer in plant's protection office operates "ON" and "OFF" control circuits of contactors at preset times of day. Can be over-ridden by master manual pushbutton control.
To L.P. I-25A. IP. A.C.B. 2 No. 10 - 3/4"C.
Control voltage 208 volts
2 No. 8-3/4"C. to 35A 2P. in L.P.
To L.P. 120 volts
On
Off
Master manual control from push-button station in plant's protection office
3 No. 10-3/4"C. to L.P. 2-25A IP. A.C.B's
Type I contactor
To floodlights
120-v
3 No. 8-3/4"C.
3 No. 10-3/4"C. to L.P. 2-25A. IP. A.C.B's
480-v 3-ϕ
3 No. 2-1 1/2"C to bus duct
Type III contactor
2 No. 10-3/4"C. to L.P. I-25A. IP. A.C.B.
Type I contactor
Type II contactor
Type II contactor
Type I contactor
To floodlights and obstruction light
To parking lot floodlights
To floodlights
To floodlights and obstruction light
Contactors spread throughout the plant are fed from different panelboards and supply widespread loads as shown.

Low-Voltage (24 Volts) Relay Switching of 277-Volt Fluorescent Luminaires



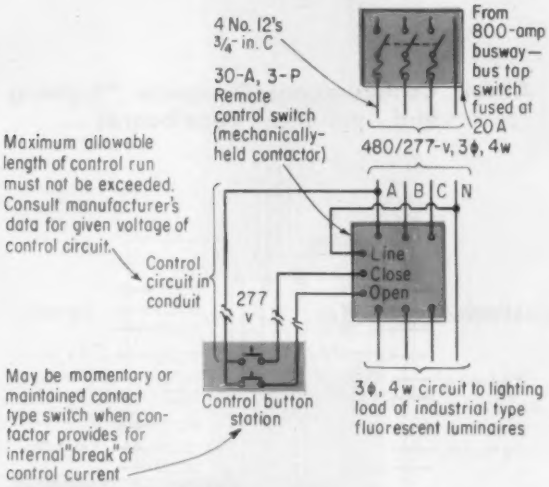
Cross-Section of Equipment Layout



Circuit Diagram of Switching Operations by 10-Amp, 277-Volt Latching Relays

LOW-VOLTAGE SWITCHING—using relays with coils rated between 6 and 24 volts—offers modern control advantages in commercial, institutional and residential buildings. Such systems are most effective where multi-point control is required for individual lighting fixtures or small groups of fixtures, where frequent switching is needed or where flexibility is important.

Remote Control Switching for Large-Block Control of Lighting


4 No. 12's 3/4" in. C
From 800-amp busway—bus tap switch fused at 20 A
30-A, 3-P Remote control switch (mechanically-held contactor)
480/277-v, 3φ, 4w
Maximum allowable length of control run must not be exceeded. Consult manufacturer's data for given voltage of control circuit.
A B C N
Line
Close
Open
Control circuit in conduit
277 v
May be momentary or maintained contact type switch when contactor provides for internal "break" of control current
Control button station
3φ, 4w circuit to lighting load of industrial type fluorescent luminaires

INDUSTRIAL APPLICATION of remote control switching can follow this basic hookup, with the individual mechanically-held contactors mounted in enclosures high up on columns in plant areas. Each contactor can be located at the approximate center of its lighting load to keep circuit wiring as short as possible for minimum voltage drop and can be tapped from the nearest point on the busway. Control circuits are then carried to one or more control panels.

Typical coil-circuit control devices include: maintained-contact and momentary-contact pushbuttons, selector switches, control and master type switches, pressure switches, float switches, limit switches, time switches, thermostats, plugging switch and contacts of control relays. Use of one or more of these devices will depend upon the nature and layout of the load. Contactors may be used for control of circuits or feeders, supplying lighting loads and/or motor loads.

Panelboards

Lighting and appliance branch circuits originate in panelboards in which the overcurrent protective devices for the circuits are mounted. In addition to the protective feature, the panelboard usually contains a means for switching each circuit. Some panelboards have a switch and fuse for each circuit; other panelboards use circuit breakers which provide both protection and switching for the circuits.

Overcurrent protection is a code requirement for branch circuits, but disconnect provisions are not required for branch circuits (although they are required to be able to disconnect fuses on circuits over 150 volts to ground and to disconnect cartridge fuses in circuits at any voltage if they are accessible to other than qualified persons). A panelboard may therefore contain only fuses. In the great majority of cases, however, the advantages of switch or CB control of each circuit at the panelboard dictate against just fuses in the panelboard. In fact, commercial and industrial practice fre-

Calculating Size of Branch Circuit Panelboards for Lighting and Appliance Circuits

Two-Wire DC or Single-Phase:

Total connected load (amperes) = sum of branch loads. At least 10 amps should be allowed for each spare or appliance circuit.

Three-Wire DC or Single-Phase:

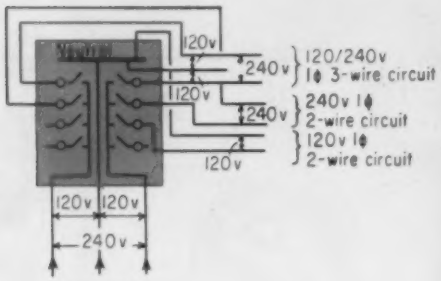
Same calculations apply as for two-wire panel, applied separately to each side of panel.

Four-Wire, Three-Phase:

The load on any bus, except the neutral, is computed the same as for a two-wire panel. Usually, the load on each of the four buses is taken as that of the most heavily loaded.

NOTE: Section 3880 of the code requires that a panelboard must have a rating (amperes capacity of its bus bars) not less than the minimum feeder capacity required for the total load. A panelboard may have a higher rating than its supply feeder, but not a lower rating.

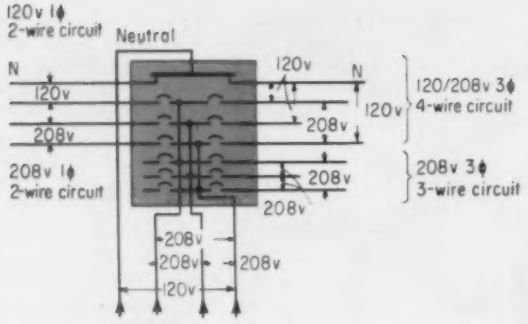
Basic Configurations for Branch Circuit Panelboards



Single-phase
3-wire feeder to typical
switch-and-fuse panel

PANELBOARD CONTAINS:

1. Phase and neutral busbars
2. Switching—
   a. Switches
   b. Circuit breakers
   c. None
3. Circuit protection—
   a. Fuses
   b. Circuit breakers



Three-phase
4-wire feeder to typical
circuit-breaker panel

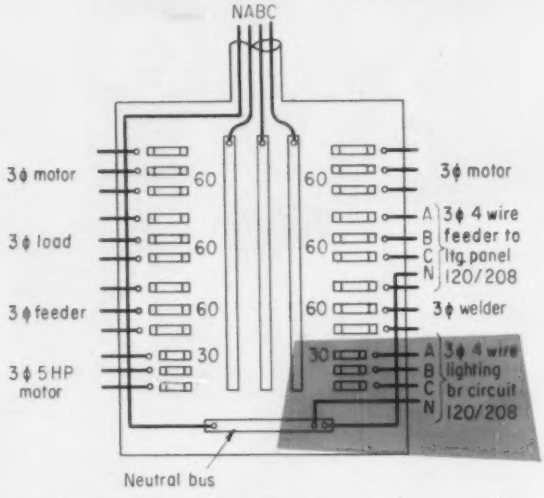
quently finds the panelboard switches or CB's used as the only control of the circuits.

Panelboards may be equipped with a main switch feeding the entire bus or a section of bus in the board. In cases where a lighting panel is supplied by a tap from a feeder protected at more than 200 amps, main protection is required for the panel and a switch or CB must be used. This single switch provides simultaneous disconnect of circuits from the feeder. In many cases, a remote control switch, operated by a time clock, is used to control the circuits connected to the bus in the panel by switching the feed to the bus.

To supplement the allowance of spare capacity in the branch circuit design work, spare circuit capacity should be allowed in panelboards. As recommended previously, one spare circuit should be allowed in the panel for each five active circuits. Inasmuch as panelboards are made in multiples of four switch-and-fuse units or circuit breakers, provision of the spare circuits can often be made without using a panelboard larger than required for the active circuits.

When spare circuits are provided in flush type panelboards, the required conduit capacity to wire these circuits should be provided to avoid future tearing out of the wall. This may consist of empty conduit runs to the ceiling and floor, terminated in covered outlet boxes, design of spare capacity in other raceways serving the branch circuit load from the panelboard, etc.

Circuit Configurations Designate "Lighting and Appliance" Panelboards



1. Total number of overcurrent devices—24.
2. Number of overcurrent devices rated 30 amps or less and for which neutral connections are provided—3.
3. 10% of the number of overcurrent devices (24) is 2.4.
4. Panelboard therefore has more than 10% of its overcurrent devices rated 30 amps or less, with neutral connections.
5. Such a panelboard is designated by the NEC as a "lighting and appliance" panelboard and must be protected on its supply side not in excess of its rating when the panelboard is tapped from conductors protected at more than 200 amps.

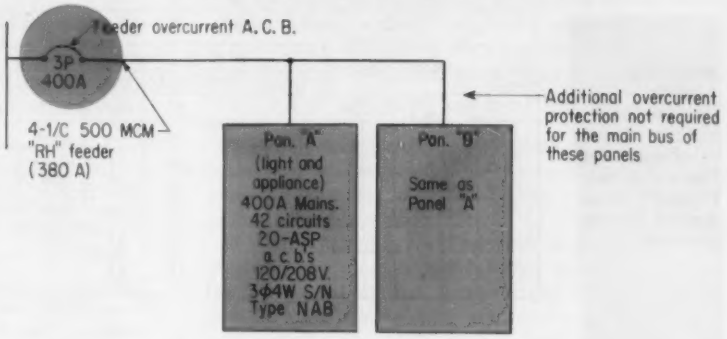
Special Case of Overcurrent Protection for Lighting and Appliance Panelboards

1 Panels A & B are fed by conductors protected at more than 200 amps.

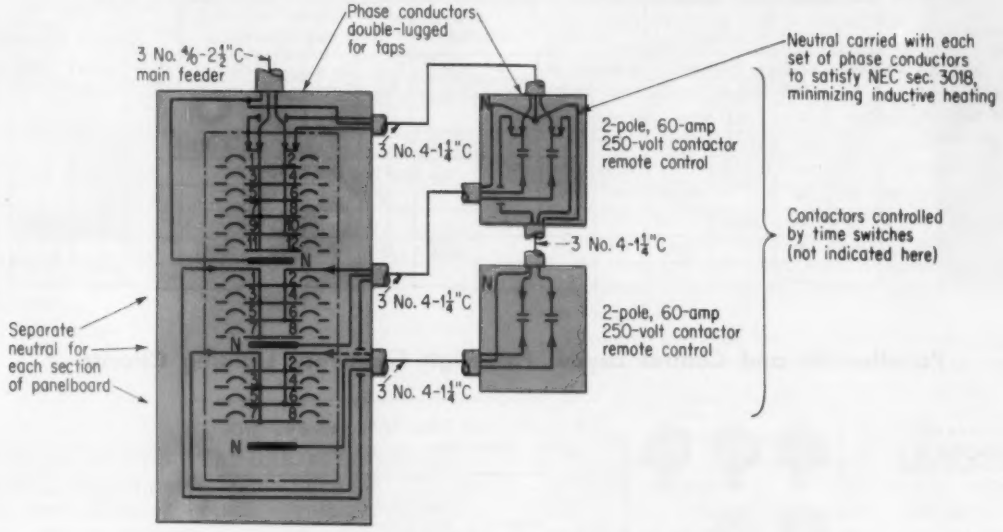
2 Such panels, which are lighting and appliance panels as defined in Sec. 3881 of the NEC, must be protected not in excess of their rating, per Sec. 3883a.

3 But each panel is rated at 400 amps.

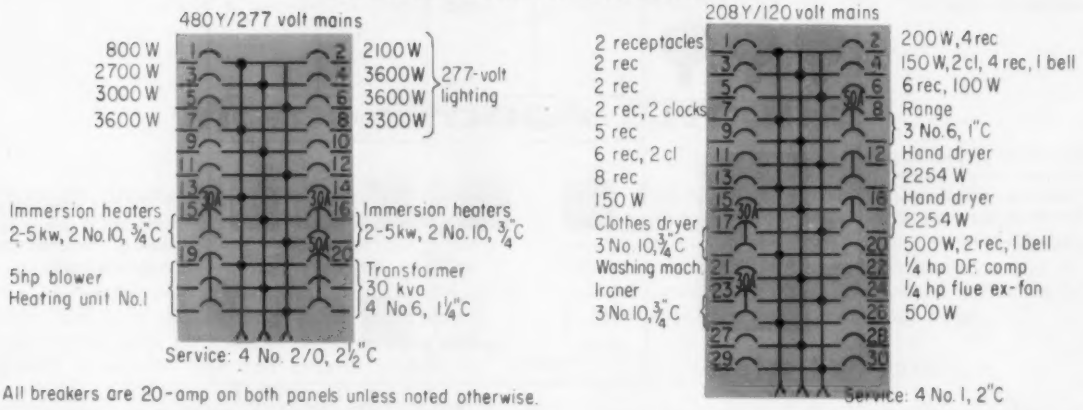
4 The feeder protection at 400 amps therefore satisfies the code requirements for protection of the panels.



Split-Bus Panelboard with contactor Controls for Sections of Main Bus



Loading Schedules for Panelboards



Note: All breakers are 20-amp on both panels unless noted otherwise.

TYPICAL PANEL SCHEDULES for load center in 480/277-volt distribution system serving a modern school. Panel capacities of similar makeup and loading are installed in each of four mechanical rooms which are distribution load centers for the classroom wings of the school building. Supply to this load center is made by four No. 2/0's in 2½-in. conduit run in the floor slab from the main service panelboard. Classroom and corridor lighting for each floor of each wing is supplied by 277-volt fluorescent lighting circuits from the 480/277-volt panel in each mechanical room (circuits 1 to 8 in schedule at left). The 30-kva transformer fed by circuit 20 in this panel supplies 120/208-volt power to the general purpose lighting and appliance panelboard at right. The two panels and the transformer are mounted close together in the mechanical room. Note spare circuits in 480-volt panel and the variation in number of receptacle outlets connected to 120-volt circuits at right. Layout and circuiting of receptacles were based on study of likely loads, possible simultaneous use of appliances and habits of use of electrical appliances. In home economics classroom, for example, heavy appliance loads and sewing machine desks dictated use of only two receptacles per No. 12 two-wire circuit.

Typical Examples of Branch Circuit Data Tabulated For Use on Electrical Plans

Basic Schedule
Lists equipment makeup of each panelboard and feeders or subfeeders. Gives general location of panels.

LIGHTING PANELBOARD SCHEDULE

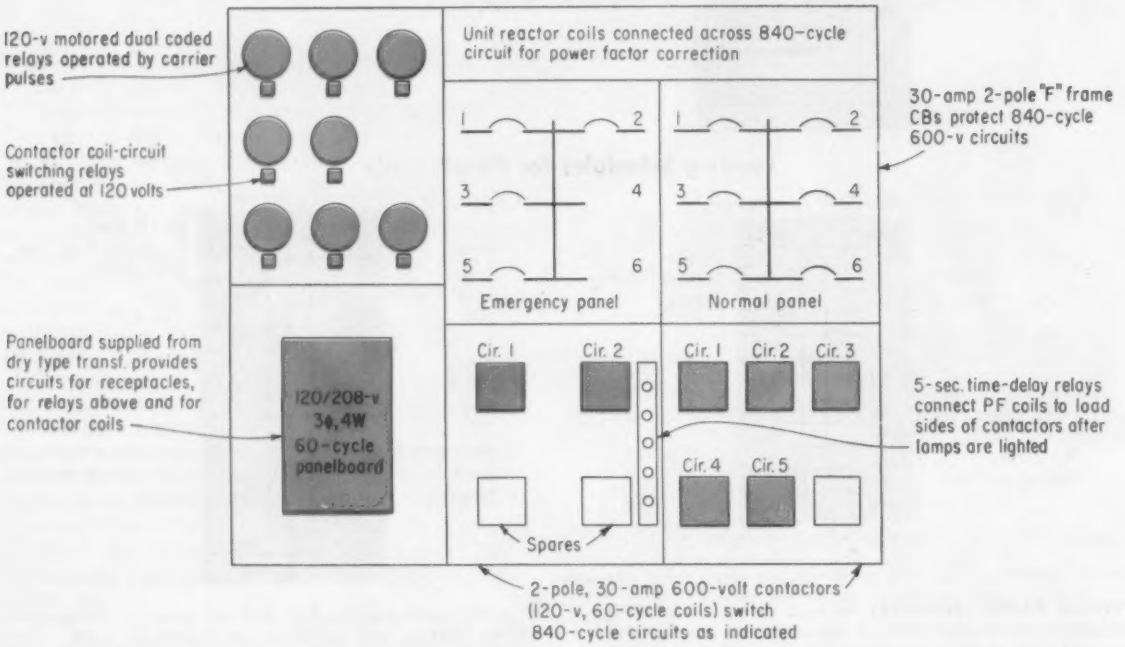
Panel Designation	Location	Equip	Branch Circuits					Mains		Service			Remarks
			No. Active	No. Spares	Total No.	Poles	Trip Calibr.	Type	Cap	Phase	Feed	Voltage	
LP1A	1st fl. Stair No. 5	Ckt. Bkr.	25	7	32	SP	20A	Ckt. Bkr.	225/125	3	4-300MCM	120/208	
LP1B	1st fl. Main stair		27	7	34	SP	20A	"	225/150	3	4-4/0	"	
LP2A	2nd fl. Stair No. 6		29	7	36	SP	20A	"	225/150	3	4-300MCM	"	
LP2B	2nd fl. Stair No. 1		1/22	1/8	2/30	2P/SP	20A/20A	"	225/125	3	4-4/0	"	
LP2C	2nd fl. Main stair		14	6	20	SP	20A	"	100/70	3	4-4/0	"	
LP3A	3rd fl. Stair No. 6		39	3	42	SP	20A	"	225/175	3	4-350MCM	"	
LP3B	3rd fl. Stair No. 1		1/20	1/6	2/26	2P/SP	20A/20A	"	100/100	3	4-4/0	"	

Supplementary Schedule
Details makeup and loading of each circuit in watts on panel bus bars.

CIRCUIT LOADING SCHEDULE

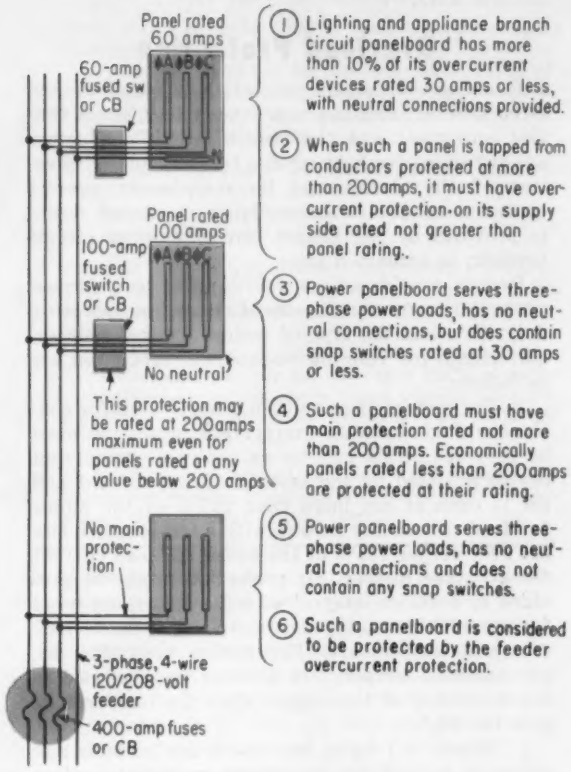
G Lighting Panelboard				K Lighting Panelboard				L Lighting Panelboard				M Lighting Panelboard			
Circ. No.	No. of Outlets	Wattage Bus A	Wattage Bus B	Circ. No.	No. of Outlets	Wattage Bus A	Wattage Bus B	Circ. No.	No. of Outlets	Wattage Bus A	Wattage Bus B	Circ. No.	No. of Outlets	Wattage Bus A	Wattage Bus B
1	4	1000		1	4	480		1	4	600		1	1	1500	
2	4		1000	2	3		1500	2	4		600	2	2		600
3	4	1000		3	3	1500		3	4	480		3	7	960	
4	4		1000	4	5		750	4	5		720	4	6		1370
5	4	1000		5	5	750		5	6	1200		5	2	1000	
6	4		1000	6	2		800	6	4		600	6	2		1000

Panelboards and Control Layout For High Frequency Lighting Circuits


120-v motored dual coded relays operated by carrier pulses
Contactor coil-circuit switching relays operated at 120 volts
Panelboard supplied from dry type transf. provides circuits for receptacles, for relays above and for contactor coils
120/208-v 3φ,4W 60-cycle panelboard
Unit reactor coils connected across 840-cycle circuit for power factor correction
1
2
3
4
5
6
Emergency panel
Normal panel
30-amp 2-pole "F" frame CBs protect 840-cycle 600-v circuits
Cir. 1
Cir. 2
Cir. 3
Cir. 4
Cir. 5
Spares
5-sec. time-delay relays connect PF coils to load sides of contactors after lamps are lighted
2-pole, 30-amp 600-volt contactors (120-v, 60-cycle coils) switch 840-cycle circuits as indicated

HIGH FREQUENCY LIGHTING branch circuits are supplied from this panelboard layout on one floor of a bank building. Feeders operating at 600 volts between conductors (300 volts to ground) and 840 cycles per second are supplied to the two CB panels at upper right, from main switchboard in frequency conversion room. Each circuit is rated 2-pole, 600 volts and protected by one 2-pole breaker. Control of circuits is made by 2-pole contactors connected on load side of branch CB's. At left, a 120/208-volt, 60-cycle panelboard provides circuits which operate the contactor coils through carrier frequency actuated relays at upper left. The carrier frequency pulses are transmitted over the 120/208-volt wiring from a central time control panel which schedules the pulse transmissions to operate the contactors at given times of the day for turning lights on or off. Relays sense the carrier pulses and close the contactor coil circuits.

Basic Rules for Panelboard Protection


Panel rated 60 amps
60-amp fused sw or CB
ΦAΦBΦC
N
Panel rated 100 amps
100-amp fused switch or CB
ΦAΦBΦC
No neutral
This protection may be rated at 200amps maximum even for panels rated at any value below 200 amps
No main protection
3-phase, 4-wire 120/208-volt feeder
400-amp fuses or CB
1 Lighting and appliance branch circuit panelboard has more than 10% of its overcurrent devices rated 30 amps or less, with neutral connections provided.
2 When such a panel is tapped from conductors protected at more than 200amps, it must have overcurrent protection on its supply side rated not greater than panel rating.
3 Power panelboard serves three-phase power loads, has no neutral connections, but does contain snap switches rated at 30 amps or less.
4 Such a panelboard must have main protection rated not more than 200amps. Economically panels rated less than 200amps are protected at their rating.
5 Power panelboard serves three-phase power loads, has no neutral connections and does not contain any snap switches.
6 Such a panelboard is considered to be protected by the feeder overcurrent protection.

GENERAL DESIGN STANDARDS for selection and layout of panelboards are as follows:

- No more than 42 branch circuit phase conductors (i.e., 42 one-pole protective devices) may originate from a single panelboard.
- No branch circuit in a panelboard should run more than 100 ft to the first outlet of the circuit.
- All panelboards should be readily accessible.
- Panelboards should be placed as near as possible to the center of the load they handle.
- If circuit switching from the panelboard is desired, a switch-and-fuse or CB panelboard must be used.
- Panelboard locations should be selected to conform as much as possible to the routing of feeders, assuring shortest possible feeder runs and minimum of bends.
- Every panelboard must have a rating not less than the minimum feeder capacity required to serve the load as determined from Article 220 of the code.
- At least one lighting and appliance branch circuit panelboard should be provided on each active floor of the building.

When lighting and appliance branch circuits, with their controls and panelboards, have been laid out, a panelboard schedule should be made up and included in the plans and specifications. This schedule should give some code letter designation to each panelboard—such as L1a for lighting panel "a" on the first floor, L2b for lighting panel "b" on the second floor, etc.—and should tabulate panel locations, number and size of circuits in each panel, type and rating of circuit protective devices, capacity of mains, size and type of main protection and disconnect and any pertinent remarks about each panelboard which might clarify design intent for the installer.

It should be noted that the code defines a lighting and appliance branch circuit panelboard as one having more than 10% of its overcurrent devices rated 30 amps or less, for which neutral connections are provided, as previously explained.

Overcurrent protection for panelboards should be carefully considered. A lighting and appliance branch circuit panelboard which is fed by a feeder protected at more than 200 amps must be protected on its supply side by overcurrent devices rated not greater than the amp rating of the panelboard.

Motor Branch Circuits

Design of circuits for motor loads and their controls involves careful consideration of factors and conditions which do not present serious problems in the design of ordinary lighting and appliance branch circuits.

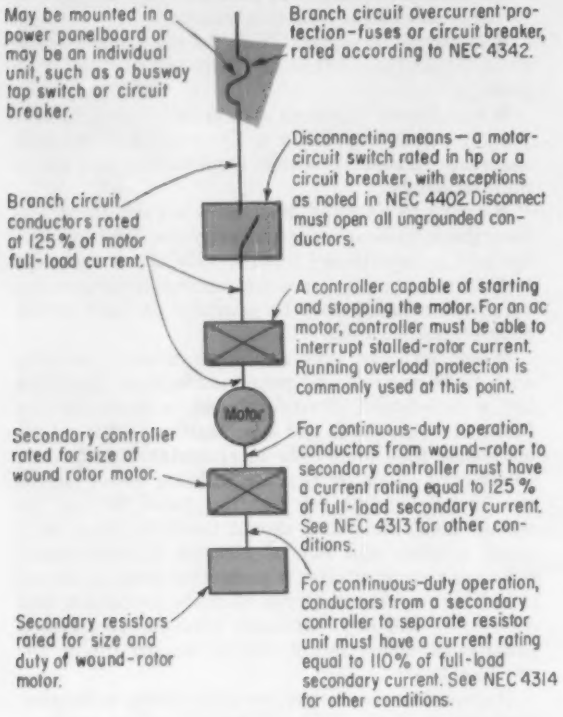
Motor loads are usually large loads and require careful wiring and protection of conductors and equipment to assure safe and reliable operation. In any plant or building, of course, the problem of providing maximum safety and reliability must be solved along with other problems—minimizing voltage drop, avoiding excessive copper loss, providing sufficient flexibility for changing locations of equipment, designing for ease and economy of maintenance of the motors and equipment and providing spare capacity in the equipment for increased loads in the future.

Basically, Article 430 of the code provides the requirements for safe and reliable operation of motor circuits. This article contains the general requirements; other articles contain specific references to motor applications—in cranes, hoists, elevators, machine tools, hazardous locations and in such occupancies as garages, service stations, bulk storage plants and other industrial areas.

Motor Currents

Except for sealed (hermetic type) refrigeration compressor motors, values for motor current ratings given in Tables 21 to 24, Chapter 10 of the code, must be used in sizing conductors, switches, branch circuit overcurrent devices, etc., instead of the motor nameplate value of current. However, the motor nameplate current should be used in determining the motor running overcurrent protection. For sealed refrigeration compressor motors, the nameplate current is used in determin-

Protection and Control Elements of Motor Branch Circuits


May be mounted in a power panelboard or may be an individual unit, such as a busway tap switch or circuit breaker.
Branch circuit overcurrent protection—fuses or circuit breaker, rated according to NEC 4342.
Disconnecting means—a motor-circuit switch rated in hp or a circuit breaker, with exceptions as noted in NEC 4402. Disconnect must open all ungrounded conductors.
Branch circuit conductors rated at 125% of motor full-load current.
A controller capable of starting and stopping the motor. For an ac motor, controller must be able to interrupt stalled-rotor current. Running overload protection is commonly used at this point.
Motor
Secondary controller rated for size of wound rotor motor.
For continuous-duty operation, conductors from wound-rotor to secondary controller must have a current rating equal to 125% of full-load secondary current. See NEC 4313 for other conditions.
Secondary resistors rated for size and duty of wound-rotor motor.
For continuous-duty operation, conductors from a secondary controller to separate resistor unit must have a current rating equal to 110% of full-load secondary current. See NEC 4314 for other conditions.

ing size of conductors, circuit overcurrent protection and motor running overcurrent protection.

Size of Conductors

Branch circuit conductors serving only one motor must have a current-carrying capacity not less than 125% of the full-load current rating of the motor. Branch circuit conductors supplying two or more motors must have a current-carrying capacity not less than 125% of the full-load current of the largest of the motors plus the sum of the full load currents of the other motors supplied. Particular design considerations may considerably increase the size of motor circuit conductors.

Section 4312 of the code also includes requirements for sizing individual branch circuit wires serving motors used for short-time, intermittent, periodic or other varying duty. In such cases, frequency of starting and duration of operating cycles impose varying heat loads on conductors. Conductor sizing therefore varies with the application.

Conductors connecting the secondary of a wound-rotor induction motor to the controller must have a carrying capacity at least equal to 125% of the motor's full-load secondary current if the motor is used for continuous duty. If the motor is used for less than continuous duty, the conductors must have capacity not less than the percentage of full-load secondary current given in the table of Section 4312. Conductors from the secondary of a wound rotor induction motor to its starting resistor must have a capacity rating in accordance with the duty classification of the resistor as given in the table of Section 4313.

Overload Protection

Running overcurrent protection in motor branch circuits is intended to protect the motors, motor control equipment and the branch circuit conductors against excessive heating due to overloads. Protection of the circuit and its components against overcurrents due to short-circuit or ground faults is provided by the branch circuit fuse or circuit breaker, as explained later.

Design considerations for running overcurrent protection vary with the size of motor, the operating duty cycle and the type of motor. Typical code requirements for running overcurrent protection are as follows:

1. For motors of more than 1 hp, if used for continuous duty, running overcurrent protection must be provided. This may be an external overcurrent device actuated by the motor running current and set to open at not more than 125% of the motor full-load current for motors with a temperature rise not over 40C or 115% of the motor full-load current for all other motors. Or protection might be provided by a device integral with the motor, approved for use with the motor and responsive to motor current and temperature. For motors over 1500 hp, an embedded temperature detector may be used to cause opening of the supply when the temperature gets too high.

2. Motors of 1 hp or less which are portable and manually started are considered protected against overcurrent by the branch circuit protection if the motor is within sight from the starter. Running overcurrent devices are not required in such cases. A distance of over 50 ft is considered out of sight.

The code states that branch circuit overcurrent protective devices which serve as running overcur-

Calculating Motor Load Currents for Sizing Circuit Conductors

1. For continuous-duty motors, the load on the branch circuit feeding a single motor is taken as 125% of the full-load rated current of the motor.
2. The load on a branch circuit supplying a motor in a class of service having short-time duty depends upon the type of loading. In most cases, the load is not greater than the percentages of full-load rated current given in table of Sec. 4312 of the NEC.
3. The load on conductors connecting the secondary of a wound rotor induction motor to its controller is taken as 125% of the rated full-load secondary current for continuous-duty motors, and not less than the percentages of full-load current for short-time duty motors given in table of Sec. 4312 of the NEC. Sec. 4313, NEC, covers load on conductors connecting the controller with secondary resistors.
4. The load on conductors supplying two or more motors is taken as not less than 125% of the full-load current rating of the highest rated motor in the group plus the sum of the full-load current ratings of the remainder of the motors in the group.
5. The load on conductors supplying motors and, in addition, lighting or appliances, is taken as the sum of the separate motor load and lighting or appliance load.

Basic Requirements for Motor Running Overload Protection

1. Motors over 1 hp, under 1500 hp and without an integral thermal protector—
   Protective device set for not more than 125% of motor full-load current for motors having a temperature rise not over 40C, or set for not more than 115% for motors of other types.
2. Portable motors of 1 hp or less, manually started and within sight from the starter location—
   The branch circuit overcurrent device is sufficient running overcurrent protection.
3. Motors of 1 hp or less, automatically started; motors of 1 hp or less, manually started and out of sight from the starter location; or motors of 1 hp or less which are not portable—
   For motors without integral thermal protectors, protective device set for not more than 125% of motor full-load current for motors having a temperature rise not over 40C, or set for not more than 115% for motors of other types.
4. No provisions are required for motors which have sufficiently high winding impedance or control devices which prevent damage due to stalled rotor.

rent protection for motors of 1 hp or less, as above, must conform to maximum sizes as given in Table 20, Chapter 10, for the particular motor current. One exception is made to this requirement on size of branch circuit protection for such cases: any motor of 1 hp or less, as above, can be used on circuits rated no more than 125 volts and protected at 20 amps, without separate running protection.

It should be noted that any motor of 1 hp or less which is not portable, is not manually started and/or is not within sight from its starter location must have specific running overcurrent protection as in the following paragraph.

3. Automatically started motors of 1 hp or less must be protected against running overcurrent in the same way as motors rated over 1 hp. That is, a separate overcurrent device or an integral device. In the case of such a motor, however, it may be considered protected against running overcurrent if it is part of an approved assembly "which does not subject the motor to overloads and which is also equipped with other safety controls (such as the safety combustion controls of a domestic oil burner) which protect the motor against damage due to stalled rotor current." Or if the impedance of the winding of a motor is high enough to prevent overheating with stalled rotor, the branch circuit protection is considered running protection.

The branch circuit protection is considered sufficient protection against running overcurrent for motors which have inherently short duty cycles—intermittent, periodic or varying duty. A motor is considered to be used for continuous duty unless the nature of the load it drives is such that it cannot operate continuously under any condition of use.

Branch Circuit Protection

Code provisions for the protection of branch circuit conductors feeding motors are covered in Sections 4341 to 4349. The overcurrent device protecting an individual motor branch circuit must be able to carry the motor starting current. It must have time delay to allow the motor to start and come up to speed. Tables 26 and 27 in Chapter 10 of the code give the required overcurrent rating values for various motor loads. Table 20 in Chapter 10 gives ratings of fuses and circuit breakers for circuit overcurrent protection.

A single branch circuit may be used to supply two or more motors as follows:

1. Two or more motors, each rated not more than 1 hp and each drawing not over 6 amps full-load current, may be used on a branch circuit protected at not more than 20 amps at 125 volts or less, or 15 amps at 600 volts or less. Individual running overcurrent protection must be provided in accordance with the previously discussed requirements for motors rated 1 hp or less and is generally necessary in such circuits.

2. Two or more motors of any rating may be connected to one branch circuit if each motor has run-

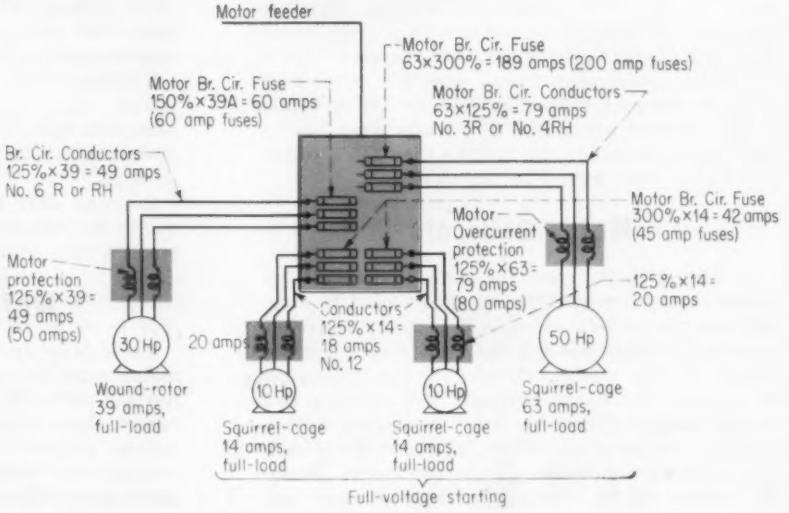
Typical Motor Branch Circuit Calculations

DATA FROM TABLE 20, NEC or as follows:

1—BRANCH CIRCUIT PROTECTION from Tables 26 and 27

2—BRANCH CIRCUIT CONDUCTORS sized according to NEC 4312

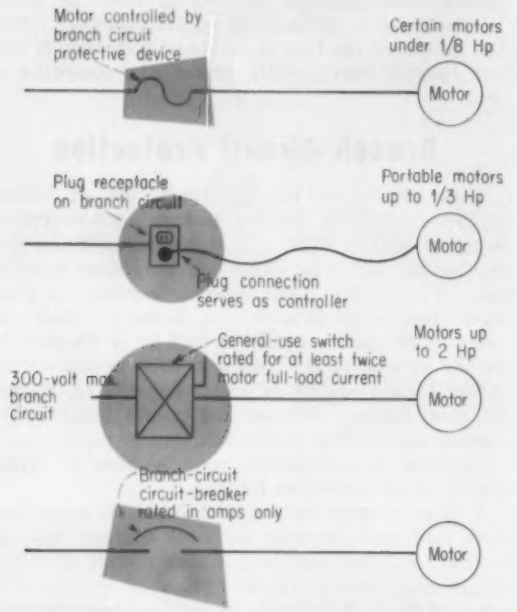
3—RUNNING OVERLOAD PROTECTION sized according to NEC 4322a



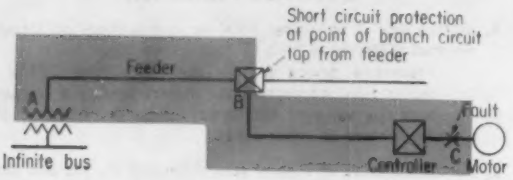
Minimum Design Requirements for Motor Controllers

A Motor Controller—

1. **Must be capable of starting and stopping the motor it controls.**
2. **For ac motors, must be capable of interrupting stalled-rotor current of the motor.**
3. **Must have a hp rating not less than that of the motor it serves, except as follows:**


Motor controlled by branch circuit protective device
Certain motors under 1/8 Hp
Motor
Plug receptacle on branch circuit
Portable motors up to 1/3 Hp
Motor
Plug connection serves as controller
General-use switch rated for at least twice motor full-load current
Motors up to 2 Hp
300-volt max. branch circuit
Motor
Branch-circuit circuit-breaker rated in amps only
Motor

Effective Short-Circuit Protection



A short-circuit fault at C will draw current until the circuit is opened by the protection at B. The value of the short-circuit current available at C depends upon the kva rating of the supply transformer, the percent reactance of the transformer, the secondary voltage and the effective impedance of the current path from the transformer to the point of fault. Application of motor controllers must, therefore, be coordinated with branch circuit overcurrent protection which must be able to safely interrupt the short-circuit current. And not only must the device be rated to interrupt the fault current, it must act quickly enough to open the circuit before let-through current can damage the controller.

Manual Starter as Controller and Disconnect

A manual starting switch—capable of starting and stopping a given motor, capable of interrupting the stalled-rotor current of the motor and having the same hp rating as the motor—may serve the functions of controller and disconnecting means in many motor circuits, if the switch opens all ungrounded conductors to the motor. This is permitted by Section 4407 of the code. An important exception to this allowance, however, is made in the case of a compensator type of controller. Such controllers must be provided with a separate means for disconnecting controller and the motor.

ning overcurrent protection, the overcurrent devices and controllers are approved for group installation, the branch circuit fuse rating is in accordance with Tables 26 and 27 for the largest motor plus the sum of the full-load current ratings of the other motors. The branch circuit fuses must not be larger than four times the rating of the thermal cutout or relay protecting the smallest motor of the group, unless the thermal device is approved for group installation with a given maximum size of short-circuit protective device.

Devices (other than fuses) used for motor running overcurrent protection and circuit breakers used to protect motor branch circuits must have a continuous current rating not less than 115% of the full-load current rating of the motor.

Motor Controls

According to the code, the term "controller" includes any switch or device normally used to start and stop the motor. In general, a motor controller must have a horsepower rating not lower than the rating of the motor. Motors under one-eighth horsepower which are normally left running and are not subject to damage from overload or failure to start, such as clock motors, may use the branch circuit protective device as the controller. Portable motors up to one-third horsepower may use their plug and receptacle connection as a controller. For stationary motors up to 2 hp, and up to 300 volts, a general-use switch rated twice the full-load motor current may be used as the controller. A branch circuit breaker, rated only in amps, may be used as a motor controller.

Although motors are generally provided with individual means for control, a single controller may serve a group of motors, rated not over 600 volts, under the same conditions as a single disconnect may be used, as described in the following section.

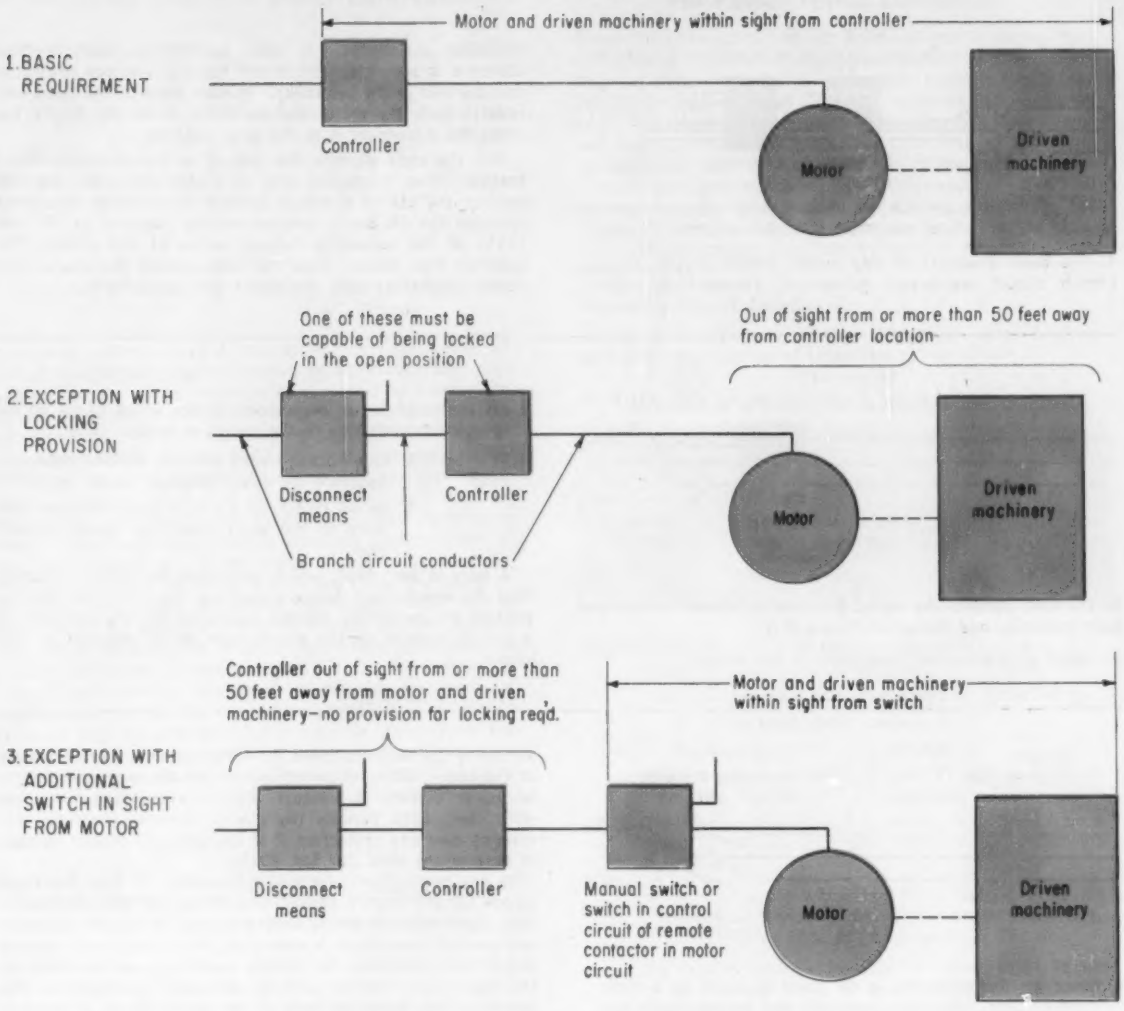
Sections 4421 to 4425 cover requirements for motors rated over 600 volts. Article 710 of the code deals specifically with "Circuits and Equipment Operating at More Than 600 Volts Between Conductors."

Sections 4371 to 4374 of the code give requirements for remote-control circuits used with motor loads.

Motor Disconnects

Depending upon the size and application of a motor, some provision must be made for disconnecting the motor from the line for maintenance and repair. General requirements for motor disconnects call for a motor-circuit switch rated in horsepower or a circuit breaker. Exceptions to this requirement are as follows:

Installed Location of Motor Controller


1. BASIC REQUIREMENT
Motor and driven machinery within sight from controller
Controller
Motor
Driven machinery
2. EXCEPTION WITH LOCKING PROVISION
One of these must be capable of being locked in the open position
Out of sight from or more than 50 feet away from controller location
Disconnect means
Controller
Branch circuit conductors
Motor
Driven machinery
3. EXCEPTION WITH ADDITIONAL SWITCH IN SIGHT FROM MOTOR
Controller out of sight from or more than 50 feet away from motor and driven machinery—no provision for locking reqd.
Motor and driven machinery within sight from switch
Disconnect means
Controller
Manual switch or switch in control circuit of remote contactor in motor circuit
Motor
Driven machinery

1. The branch circuit overcurrent device may serve as the disconnecting means for stationary motors rated one-eighth horsepower or less.

2. A general-use switch rated at twice the motor full-load current rating may be used as the disconnecting means for stationary motors rated at 2 hp or less and 300 volts or less.

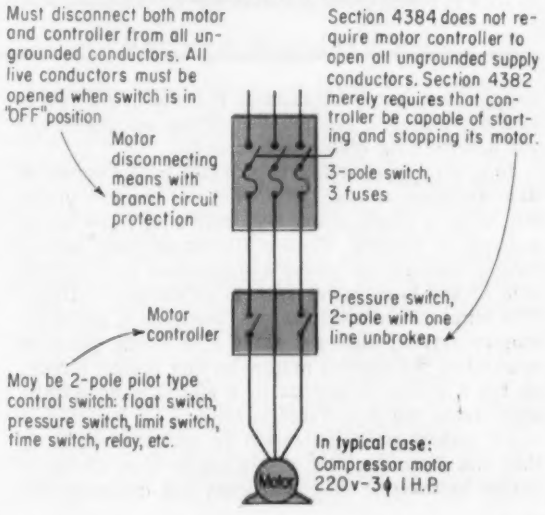
3. From 2 to 50 hp, motors used with compensator types of controllers may have a general-use switch for the disconnecting means under conditions given in Section 4402 of the code.

4. Motors over 50 hp may have a motor-circuit switch also rated in amps, a general-use switch or an isolating switch as a disconnect.

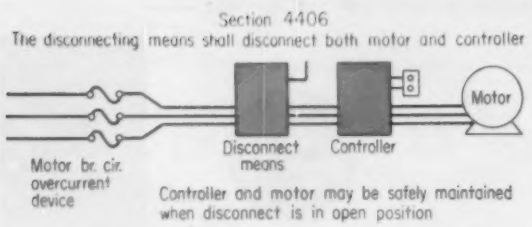
5. The plug and receptacle used for connecting portable motors to their circuits may serve as the disconnecting means.

In a motor branch circuit, every switch in the circuit in sight from the controller must satisfy the foregoing requirements. And the disconnect switch must be able to carry at least 115% of the nameplate current rating of the motor. It must disconnect both the motor and the controller from all

Motor Controller Need Not Open All Conductors to Motor

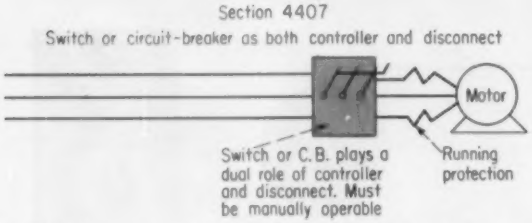

Must disconnect both motor and controller from all ungrounded conductors. All live conductors must be opened when switch is in "OFF" position
Section 4384 does not require motor controller to open all ungrounded supply conductors. Section 4382 merely requires that controller be capable of starting and stopping its motor.
Motor disconnecting means with branch circuit protection
3-pole switch, 3 fuses
Pressure switch, 2-pole with one line unbroken
Motor controller
May be 2-pole pilot type control switch: float switch, pressure switch, limit switch, time switch, relay, etc.
In typical case: Compressor motor 220v-3φ 1 H.P.
Motor

Circuit Breaker As Multiple Element in Motor Branch Circuit


Section 4406
The disconnecting means shall disconnect both motor and controller
Motor
Disconnect means
Controller
Motor br. cir. overcurrent device
Controller and motor may be safely maintained when disconnect is in open position

1. The basic elements of any motor branch circuit include: branch circuit overcurrent protection, disconnecting means, controller and motor. In many applications, each of these elements is separate, with motor running overload protection incorporated in the controller. In such circuits, the disconnect isolates both the motor and controller from the supply line when the disconnect is in the open position.

But the code permits the use of a branch-circuit circuit breaker, rated in amperes only, as a controller. And the code permits the use of a circuit breaker as a motor disconnect, provided the CB has a current-carrying capacity of at least 115% of the nameplate current rating of the motor. The question then arises—Does the code permit the use of one circuit breaker as both disconnect and controller?


Section 4407
Switch or circuit-breaker as both controller and disconnect
Motor
Switch or C.B. plays a dual role of controller and disconnect. Must be manually operable
Running protection

2. The code permits the use of a switch or circuit breaker as both controller and disconnect means if it—

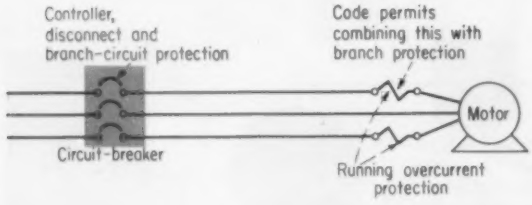
A. opens all ungrounded conductors to the motor,

B. is protected by an overcurrent device which opens all ungrounded conductors to the switch or breaker, and

C. is either—A. an air-break switch or circuit breaker, manually operable by direct coupled handle, or

b. an oil switch on a circuit rated not over 600 volts or 100 amps (unless by special permission).

A note in Sec. 4407, which sets forth the above, indicates that the overcurrent device protecting the controller may be part of the controller, thereby qualifying the trip elements in a circuit breaker as the overcurrent device required in "B" above.



3. Based on the foregoing, a CB could be used as a three-function element: disconnect, controller and branch circuit overcurrent protection. For branch circuit protection, a CB must have a continuous current rating of not less than 115% of the full-load current rating of the motor.

Further, Sec. 4344 permits the use of one overcurrent device to serve as branch circuit protection and running overload protection if the device satisfies the maximum rating requirements of the code—125% of motor current for 40C motors or 115% of motor current for motors with a temperature rise over 40C. Sec. 4329 permits the use of a motor controller for running overload protection if it contains the proper number of overcurrent units (per Sec. 4327).

In any application, practical achievement of four functions in one CB will require careful engineering for effective operation. Application of circuit breakers (large air circuit breakers and molded case circuit breakers) as short circuit and running overcurrent protection for motors must be based on study of the time-current heating curve for the motor in relation to the operating-time tolerance band of the type and size of breaker to be used. Protection must be provided against overheating due to running overload and stalled rotor in excess of the motor's heating curve. Time delay and instantaneous trips, whether adjustable or non-adjustable, must be related to the requirements.

---

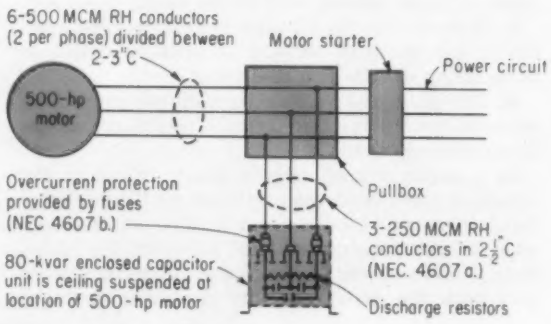
ungrounded supply conductors For sealed refrigeration compressors, Section 4403 gives the procedure for determining disconnect capacity.

In general, each motor is provided with a separate disconnecting means. However, for motors under 600 volts, a single disconnect may sometimes serve a group of motors. Such a disconnect must have a rating sufficient to handle a single load equal to the sum of the horsepower ratings or current ratings. The single disconnect may be used for a group of motors driving different parts of a single piece of apparatus, for several motors on one branch circuit or for a group of motors in a single room within sight from the disconnect location.

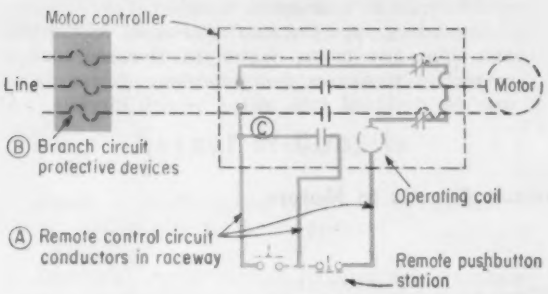
An important requirement in motor circuits is that the disconnect be within sight from the controller location or be constructed and designed for

Typical Arrangement for PF Capacitor at Motor Terminals

(See NEC Article 460)

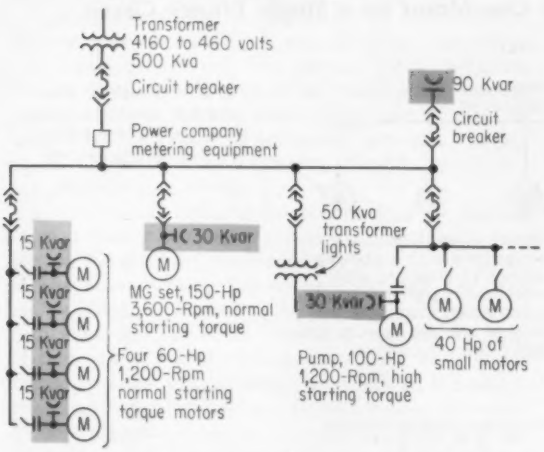

6-500 MCM RH conductors (2 per phase) divided between 2-3"C
Motor starter
Power circuit
500-hp motor
Overcurrent protection provided by fuses (NEC 4607 b.)
Pullbox
3-250 MCM RH conductors in 2½"C (NEC. 4607 a.)
80-kvar enclosed capacitor unit is ceiling suspended at location of 500-hp motor
Discharge resistors

Hookup and Protection of Remote Control Circuits for Magnetic Motor Controllers



In general, remote control conductors must be protected against overcurrent. Section 2403-g of the code states that such conductors can be satisfactorily protected by overcurrent devices which are not of the time-lag type and are rated at not more than 500% of the carrying capacity of the control circuit conductors. Section 4372, however, modifies this requirement for motor control circuits as follows: The remote control conductors above (A) may be properly protected by the branch circuit overcurrent devices (B) if these devices are rated or set at not more than five times the current rating of the control conductors. If the branch circuit overcurrent devices were rated or set at more than five times the rating of the control conductors, the control conductors would have to be protected by separate protective devices located "at the point where the conductor to be protected receives its supply" (C). And in the case of motor control circuits, the branch circuit protective devices may be of the time-lag type and still qualify as protection for the control conductors. It should be noted that the overcurrent protection is required for the control conductors and not for the operating coil. Because of this, the size of control conductors can be selected to allow application without separate overcurrent protection.

Mount Capacitors at Motor Terminals for Most Effective PF Correction



Power factor capacitors installed at terminals of motors provide maximum relief from reactive currents, reducing the required current-carrying capacities of conductors from their point of application all the way back to the supply system. Such application also eliminates extra switching devices, since each capacitor can be switched with the motor it serves. When motors are small, numerous and operated intermittently, however, it is often economically more desirable to install required capacitor kvar at the motor load center.

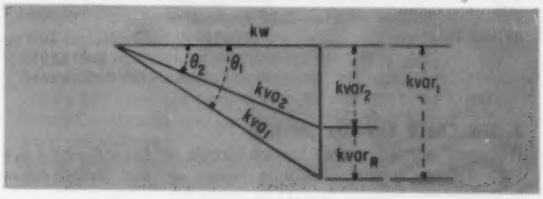
Application of Capacitors For Power Factor Correction

Power factor capacitors can be connected across electric lines to neutralize the effect of lagging power-factor loads, thereby reducing the current drawn for a given kilowatt load. In a distribution system, small capacitor units may be connected at the individual loads or the total capacitor kilovolt-amperes may be grouped at one point and connected to the main. Although the total kvar of capacitors is the same, the use of small capacitors at the individual loads reduces current all the way from the loads back to the scource and thereby has greater PF corrective effect than the one big unit on the main, which reduces current only from its point of installation back to the source.

Calculating Size of Capacitor:

Assume it is desired to improve the power factor a given amount by the addition of capacitors to the circuit.

Then $kvar_R = kw \times (\tan \theta_1 - \tan \theta_2)$



where $kvar_R$ = rating of required capacitor
$kvar_1$ = reactive kilovolt-amperes at original PF
$kvar_2$ = reactive kilovolt-amperes at improved PF
θ_1 = original phase angle
θ_2 = phase angle at improved PF
kw = load at which original PF was determined.

NOTE: The phase angles θ_1 and θ_2 can be determined from a table of trigonometric functions using the following relationships:

θ_1 = The angle which has its cosine equal to the decimal value of the original power factor (e.g., 0.70 for 70% PF; 0.65 for 65% PF; etc.)

θ_2 = The angle which has its cosine equal to the decimal value of the improved power factor.

---

locking in the open position. A distance of over 50 ft is considered out of sight.

Voltage Regulation

To assure proper and efficient operation of motors, the matter of voltage regulation must be considered carefully. Many factors—number of motors, sizes and types of motors, duty cycles, load densities, type of distribution system, loading of various feeders, power factor—are related to the design problem of assuring necessary level and stability of voltages for motors. The matter of voltage regulation follows through every step in design and must be accounted for in sizing conductors and selecting equipment for the system.

Voltage drop from the source of voltage supply to any motor in the system must not exceed 5%. Normally, proper power feeder design will limit voltage drop to 3%, leaving a maximum permissible voltage drop of 2% in any motor branch circuit under full-load conditions. However, a 1% maxi-

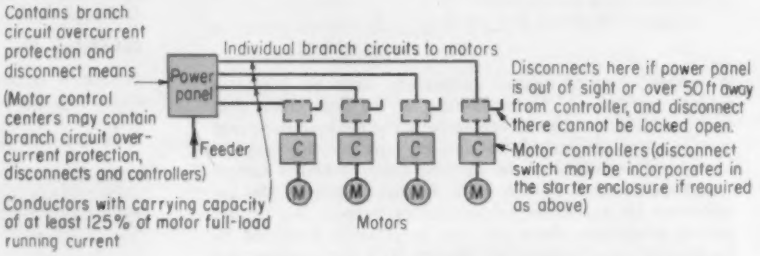
mum circuit drop is recommended. To meet this requirement, assuring all the advantages of motor operation at proper value, voltage drop calculations should be based on all of the previously mentioned factors which affect voltage drop.

Copper loss due to conductor resistance and current flow represents a power loss in heat and should be minimized by up-sizing the conductors where the motor will be running at or near full load for long periods. Power factor should be taken into consideration in all calculations, using the known value of PF or an 80% assumed value.

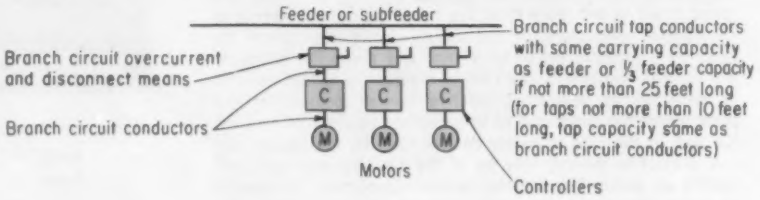
Depending upon the results of study of the voltage drop and power factor relationship, use of corrective measures for improving power factor may be designed into motor branch circuits. At

Layouts for Individual Branch Circuits to Motors

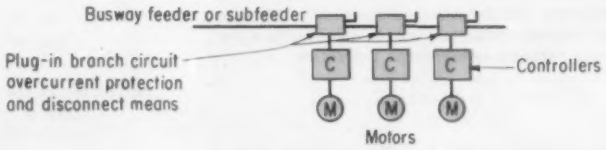
1. THE CONTROL CENTER LAYOUT
Branch circuit protective devices for motor circuits are grouped, sometimes with required controller and disconnect equipment. Offers economy where it can be functionally incorporated. Grouping may be made in one enclosure—power panel or control center assembly—or may consist of a number of individual enclosures at one location.


Contains branch circuit overcurrent protection and disconnect means
(Motor control centers may contain branch circuit overcurrent protection, disconnects and controllers)
Individual branch circuits to motors
Power panel
Feeder
Disconnects here if power panel is out of sight or over 50 ft away from controller, and disconnect there cannot be locked open.
Motor controllers (disconnect switch may be incorporated in the starter enclosure if required as above)
Conductors with carrying capacity of at least 125% of motor full-load running current
Motors

2. THE CABLE TAP-BOX METHOD
Wherever needed, motor branch circuit is tapped from conduit and wire feeder or subfeeder (or busway feeder) by using 10-ft or 25-ft unprotected tap from cable junction box to branch circuit protective device.

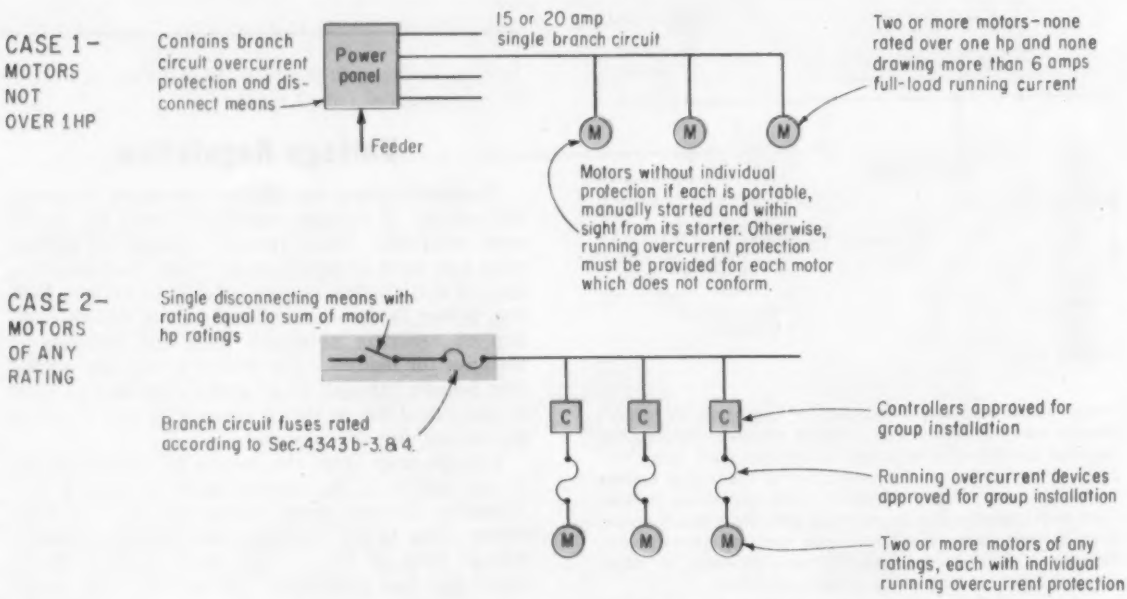

Feeder or subfeeder
Branch circuit overcurrent and disconnect means
Branch circuit conductors
Branch circuit tap conductors with same carrying capacity as feeder or 1/3 feeder capacity if not more than 25 feet long (for taps not more than 10 feet long, tap capacity same as branch circuit conductors)
Motors
Controllers

3. THE BUSWAY TAP-SWITCH METHOD
Each motor circuit is tapped from busway through a fused tap-switch or tap-CB which provides disconnect means and branch circuit overcurrent protection.



Requirements for Connecting More Than One Motor on a Single Branch Circuit

(NEC Sec. 4343)


CASE 1—
MOTORS NOT OVER 1 HP
Contains branch circuit overcurrent protection and disconnect means
Power panel
Feeder
15 or 20 amp single branch circuit
Two or more motors—none rated over one hp and none drawing more than 6 amps full-load running current
Motors without individual protection if each is portable, manually started and within sight from its starter. Otherwise, running overcurrent protection must be provided for each motor which does not conform.
CASE 2—
MOTORS OF ANY RATING
Single disconnecting means with rating equal to sum of motor hp ratings
Branch circuit fuses rated according to Sec. 4343 b-3 & 4.
Controllers approved for group installation
Running overcurrent devices approved for group installation
Two or more motors of any ratings, each with individual running overcurrent protection

individual motor locations, power-factor-correcting capacitors offer reduction in required carrying capacity and improved voltage regulation. Voltage stability as it might be affected by starting currents of motors frequently coming on is generally a consideration in feeder design but should not be overlooked in circuits serving more than one motor.

Layout of Circuits

Based on the foregoing rules and considerations, motor branch circuits can be designed for any types of occupancy.

Generally, motor circuit requirements for commercial and institutional buildings are concerned with known loads which are fairly permanent in their size and location. These loads include refrigeration and air conditioning compressors, pumps, elevators, escalators, blowers and fans. Such loads can be served by many types of wiring systems without special provisions for flexibility.

Industrial plants, on the other hand, require considerable power circuiting flexibility to accommodate moving of motors, shifting of production lines and expansion of motor loads. To provide this necessary flexibility, motor circuits may be fed from plug-in busway, from wireways, from oversize conduit and raceways which will allow change and expansion in the wiring or, in the case where many small motors are to be supplied, an underfloor raceway system.

Spare capacity for increased motor loads is a design consideration for motor feeders and subfeeders. Spare capacity should be included in the motor circuit panelboard where required. By using sectional type panelboards with interchangeable units and oversize raceway for branch circuit wiring, future increase in size of the motor on the circuit and increase in associated branch circuit equipment is greatly facilitated.

Laying out wiring to serve two or more motors may be made according to one of several plans:

1. Each motor may be served by a separate branch circuit from a panel or distribution center.
2. Individual branch circuits to motors may be tapped from a feeder or subfeeder at various points along its length of run, without using a branch circuit distribution center.
3. Individual circuits to motors may be tapped from a feeder without individual overcurrent protection for the taps, provided they are carried direct to the disconnecting means or controller for each motor. Such taps must have the same carrying capacity as the feeder if they are over 25 ft long. If they are under 25 ft long, they must have a carrying capacity at least equal to one-third the carrying capacity of the feeder. In such cases, the motor branch circuit protection is included with the disconnect means (switch and fuses, or CB) or in a combination starter, and the branch circuit originates at that point.
4. Individual branch circuits to motors may originate at controllers or disconnects fed directly by a feeder or subfeeder (e.g., tap units on a busway).
5. Two or more motors may be connected to a single branch circuit under the conditions previously given for several motors on one branch circuit.

Basic Data on Hazardous Locations

Here's how the code designates different types of hazardous locations—

Class I—Locations in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures.
Class II—Locations which are hazardous because of the presence of combustible dust.
Class III—Locations which are hazardous because of the presence of easily ignitible fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in air in quantities sufficient to produce ignitible mixtures.

Each Class of hazardous location is further subdivided into two divisions:
Division 1—Locations where the hazardous condition is continuously present.
Division 2—Locations in which the hazardous condition is not always present but in which the possibility of explosion or flash fire exists.

Various atmospheric mixtures have been grouped on the basis of their hazardous characteristics and serve to further classify hazardous locations:
Group A—Atmosphere containing acetylene.
Group B—Atmospheres containing hydrogen, or gases or vapors of equivalent hazard such as manufactured gases.
Group C—Atmospheres containing ethyl-ether vapors, ethylene or cyclo-propane.
Group D—Atmospheres containing gasoline, hexane, naphtha, benzine, butane, propane, alcohol, acetone, benzol, lacquer solvent vapors or natural gas.
Group E—Atmospheres containing metal dust including aluminum, magnesium and their commercial alloys.
Group F—Atmospheres containing carbon black, coal or coke dust.
Group G—Atmospheres containing flour, starch or grain dust.

And here are the design fundamentals for wiring in hazardous locations—

Class I Locations

Division 1—Wiring must be in rigid metal conduit with threaded explosion-proof joints and explosion-proof boxes and fittings. All outlet and junction boxes, switches, controllers and motors must be of explosion-proof design. To prevent passage of gases, vapors or flames from one portion of the electrical system to another, conduit runs must have sealing fittings not more than 18 inches from the point where the conduit enters enclosures housing equipment which may produce sparks, arcs or high temperatures. Such seals must also be installed in each conduit run of 2-inch or larger size entering the enclosure or fitting housing terminals, splices or taps, and must be within 18 inches from the enclosure. Seals must also be used in conduit runs where they leave a hazardous area to enter a non-hazardous area. All conduit and box connections must be of the threaded type.

Division 2—Requirements for explosion-proof equipment are essentially the same as for Division 1. However, conduit may be either rigid metal or electrical metallic tubing. Seals are required as set forth in Section 5015, b.-1 and b.-2.

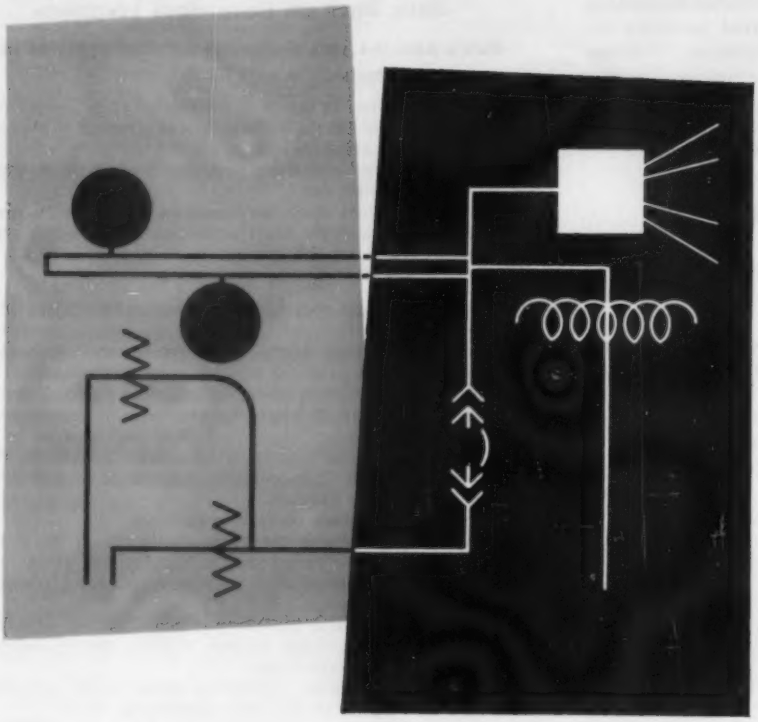
Class II Locations

Division 1—Wiring must be in rigid conduit with threaded dust-tight fittings and boxes. Other equipment must also be of dust-tight design.

Division 2—Wiring requirements are generally the same as for Division 1, but again either rigid or thinwall conduit may be used.

Class III Locations

Divisions 1 and 2 require rigid conduit with threaded fittings and boxes designed to prevent escape of sparks or flames. Fixtures, switches and controller enclosures as well as motors must be of dust-tight construction.



PROVIDE A MODERN . . .

DISTRIBUTION SYSTEM

TRANSFER of electrical energy from the source or sources of supply to the branch circuits which feed the loads is made by the distribution system. This system is a layout of equipment in various configurations designed to provide the right amount of current at the right voltage to each utilization outlet. The distribution system carries power to lighting panelboards, power panelboards, motor control centers and to the branch circuit protective devices for individual motor or power loads.

Depending upon the type of building, the size and nature of the total load, various economic factors and local conditions, a distribution system may operate at a single voltage level or may involve one or more transformations of voltage. A distribution system might also incorporate change in frequency of alternating-current power or rectification from alternating-current to direct-current power.

Design of a distribution system, therefore, is a matter of selecting circuit layouts and equipment to accomplish electrical actions and operations necessary for the conditions of voltage, current and frequency. This means relating such factors as service voltage, distribution voltage or voltages, conductors, transformers, converters, switches, protective devices, regulators and power factor corrective means to economy, load conditions, continuity of service, operating efficiency and future power requirements. Of course, the factors of capacity, accessibility, flexibility and safety must be carefully included in design considerations for distribution.

Distribution Voltages

Distribution systems are basically classified according to voltage levels used to carry the power either directly to the branch circuits or to load-center transformers or substations at which feeders to branch circuits originate.

1. 120/240-volt, 3-wire, single-phase combination light and power distribution.

This type of system is restricted to applications where the total load is small and is primarily lighting. The most common application is in residential occupancies—individual homes or multi-family dwellings. Stores, small schools and other small commercial occupancies also use this system.

In most cases of small commercial buildings, however, the use of 120/208-volt 3-phase distribution offers greater economy due to higher operating efficiency of 3-phase circuits.

In those cases where 120/240-volt feeders are used as the basic distribution method, the service to the premises is made at that voltage. Of course, 120/240-volt distribution is frequently an effective and economical system for lighting-subfeeder distribution in electrical systems which use a higher-voltage basic distribution system with load-center step-down to utilization voltages for local and incidental lighting and receptacle circuits.

2. 120/208-volt, 3-phase, 4-wire combination light and power distribution.

This is the most common type of system used in commercial buildings, in some institutional occupancies and in small industrial shops with limited electrical loads. Such a system offers substantial economy over the 120/240-volt system in the amount of copper conductor required to carry a given amount of power to a load. This combination system provides 120 volts phase-to-neutral for lighting and single-phase loads and 208 volts phase-to-phase for single- or 3-phase motor or other power loads. This distribution system is used as the basic distribution in those occupancies in which the service to the building is of the same voltage. It is also the most common sub-distribution system for lighting and receptacle circuits in those occupancies using higher-voltage distribution to load centers.

3. 240-volt, 3-phase, 3-wire distribution.

This is a common system for power loads in commercial and industrial buildings. In such cases, service to the premises is made at 240 volts, 3-phase. Feeders carry the power to panelboards or wireways supplying branch circuits for motor loads. Lighting loads are usually handled by a separate single-phase service to the building.

This system offers economic application where the power load is large compared to the lighting load. In some 240-volt, 3-phase, 3-wire systems, a grounded center tap on one of the phases is used as a neutral to provide 120 volts for lighting and receptacle circuits.

4. 480-volt, 3-phase, 3-wire distribution.

This system is commonly used in commercial and industrial buildings with substantial motor loads. Service to the building may be made at this voltage, and the 480-volt feeders carried to motor loads and to step-down transformers for lighting and receptacle circuits. In many cases, 480-volt feeders will be derived from load-center substations within the building and carried to motor loads or power panels.

5. 480Y/277-volt, (or 416/240-volt) 3-phase, 4-wire combination power and light distribution.

This has become an important system for use in commercial buildings and industrial buildings. In office and other commercial buildings, the 480-volt (or 416-volt), 3-phase, 4-wire feeders are carried to each floor where 480-volt (or 416-volt), 3-phase power is tapped to a power panel or to motors; general area fluorescent lighting using 277-volt (or 240-volt) ballasts is connected between each phase leg and the neutral; and 120/208-volt, 3-phase, 4-wire circuits are derived from step-down transformers for local lighting, appliance and receptacle circuits.

Application of this system offers economic advantage over a 120/208-volt system when less than about half of the load devices require 120- or 208-volt power. Where the 480Y system can be used, it will cost less than the 120/208-volt system due to copper savings through the use of smaller sizes of conductors and lower cost of system elements due to lower current capacities. If the required amount of 120- or 208-volt power is over half of the total load in a building, the cost of the step-down transformers to supply these circuits will offset the savings in the 480-volt circuiting. Costs of switchgear and panelboards also affect comparison of the two types of systems.

The 480Y system is generally more advantageous in multi-floor buildings than in buildings of only a few floors and more advantageous in large or long single-level areas than in small areas. The savings are directly related to reducing the sizes of long feeders, getting more kva delivered per pound of installed system.

6. 2400-volt, 3-phase delta distribution.

This is an industrial type system used to feed heavy motor loads directly and motor and lighting loads through load center substations and lighting transformers.

7. 4160Y/2400-volt, 3-phase, 4-wire distribution with a grounded neutral.

This is a more common system than the above 2400-volt, delta-connected system. Originally developed primarily for industrial applications, this system of high-voltage distribution has gained widespread use for large-area, spread-out commercial and institutional buildings, such as shopping centers, schools, motels. In fact, this system appears to have become the most popular high-voltage system for inside distribution. Economies in the use of cables and switchgear seem to be highest for this particular primary system. In

Basic Rules for Distribution Design

1. Carefully determine the magnitude and characteristics of all individual loads and load groupings.
2. Locate the one or more electrical supply points as near as possible to building load centers.
3. Select and arrange feeders and other distribution equipment to provide power continuity required by the commercial or industrial functions of the building.
4. Constantly relate the building's electrical requirements to the system characteristics of flexibility, accessibility and regulation.
5. Provide a calculated amount of spare capacity in all system components from the supply to load devices, carefully correlating feeder and subfeeder spare capacities to realistic demand and diversity expectations.
6. Use modern load center layouts where possible.
7. Do not be limited by code figures for conductors, conduit, protective devices, switches and control equipment.

many installations, this system offers the advantages of load center primary distribution for power and light loads with direct connection of heavy motor loads operating at 2400 volts or 4160 volts.

This system is widely used to supply load center substations in which the voltage is stepped to 480 to feed motors and lighting transformers for 120/240-volt and/or 120/208-volt circuits. It may also be used in distribution to substations stepping the voltage directly to 120/208.

8. 4800-volt 3-phase distribution.

This is a delta-connected industrial system for layouts of substations supplying motors and lighting transformers.

9. 7200-volt 3-phase distribution.

This is another industrial system used with substations for stepping voltage to lower levels for power and lighting.

10. 13.2Y/7.2-kv (or 13.8-kv) 3-phase, 4-wire distribution.

This is a modern, widely used distribution system for large industrial plants. Power at this voltage is delivered to substations which step the voltage to 480 for motor loads and which supply 480/120/240-volt or 480/120/208-volt transformers for lighting. Or 480Y/277-volt substations may be used to supply motor loads and 277-volt fluorescent or mercury vapor lighting for office and industrial areas. Lighting transformers are then used to supply 120-volt circuits for lighting and convenience receptacles.

The voltage values given for these distribution systems are of course subject to the usual variation or spreads due to distance of transmission and distribution, local conditions of utility supply and settings of transformer taps. In addition to the distribution voltages given, other systems may operate at 6.6 kv, 8.3 kv, 11 kv and 12 kv.

Of the high-voltage (over 600 volts) distribution systems, 4160 volts and 13,200 volts are the most common and represent good design selection and economy of application for most cases. However, selection of primary layout depends upon size and layout of load and the supply voltages which the utility makes available. Consultation with the utility must precede any design attempt at high-voltage distribution.

The trend today is toward the use of the 13-kv systems over other high-voltage distribution systems for large industrial plants and the use of 4160/2400-volt systems for spread-out commercial and institutional buildings. To some extent, primary distribution finds application in multi-floor commercial buildings, such as the use of basement and roof substations fed at high voltage and dividing the total building load. In the majority of cases, however, tall buildings can most economically be served from a secondary distribution system.

Feeder Design

In any electrical system, the "feeders" are the conductors which carry electrical power from the service equipment (or generator switchboard where power is generated on the premises) to the overcurrent protective devices for branch circuits supplying the various loads.

In some systems, feeder runs may be made directly from a main switchboard to lighting panels, power panels and/or directly to motor circuits. In other systems, feeders may be carried from a main distribution switchboard to sub-distribution switchboards or panelboards from which subfeeders originate to feed branch circuit panels or motor branch circuits. In still other systems, either or both of the two foregoing feeder layouts may be incorporated with transformer substations to step the distribution voltage to utilization levels. The following discussion covers a detailed analysis of feeder requirements for various types of distribution systems. Because descriptive terms referring to distribution systems and their elements are frequently misused and misunderstood, the following definitions are given to clarify the discussion:

MAINS are the conductors extending from the utility service terminals at the building wall (or generator or converter bus) to the service switch or to the main distribution center.

FEEDER is a set of conductors originating at a main distribution center and feeding one or more subdistribution centers, one or more branch circuit distribution centers, one or more branch circuits (as in the case of plug-in busway or motor circuit taps to a feeder) or a combination of these. It may be a primary or secondary voltage circuit, but its function is always to deliver a block of power from one point to another point at which the power capacity is apportioned among a number of other circuits.

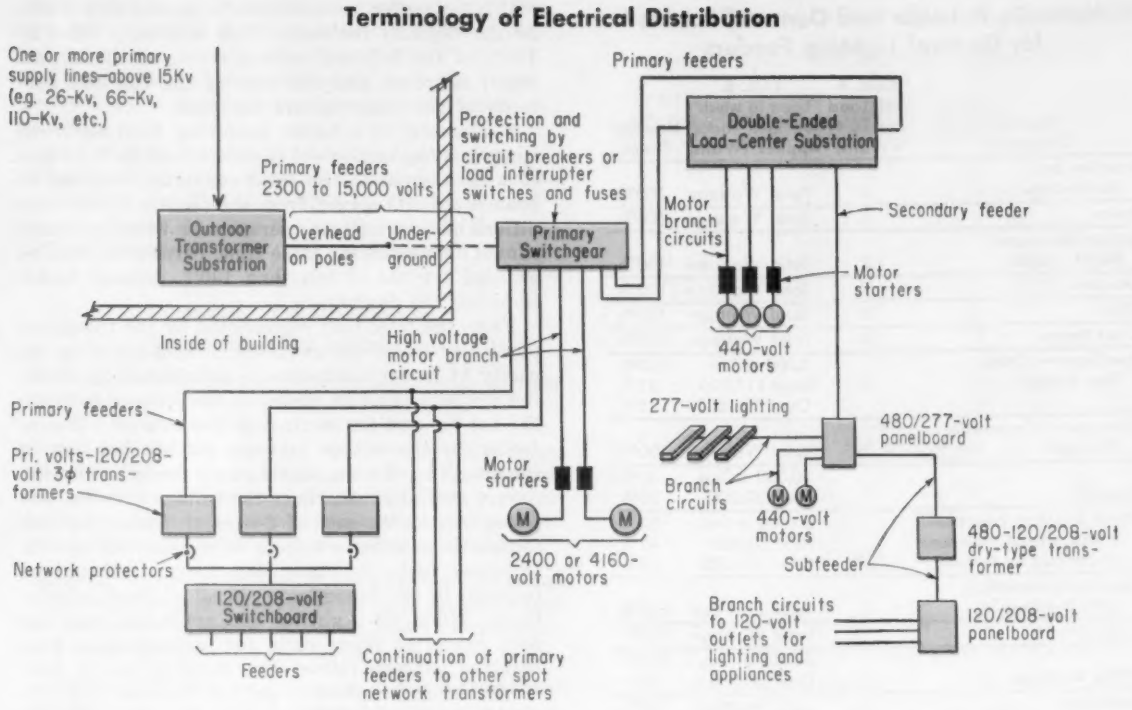
LIGHTING FEEDER is a feeder to a load which is primarily made up of lighting circuits.

POWER FEEDER is a feeder to a load of motor and/or heating or other power branch circuits.

SUBFEEDER is a set of conductors originating at a distribution center other than the main distribution center and supplying one or more branch circuit panelboards or branch circuits.

SWITCHBOARD is a large single panel, frame or assembly of panels, with switches, overcurrent and other protective devices and usually instruments mounted on the front and/or the back. Switchboards are generally accessible from the back as well as from the front and are not intended to be installed in cabinets.

PANELBOARD is a single panel or group of panel units assembled in the form of a single panel. It contains buses tapped by fuse holders, with or without switches, or by circuit breakers, providing protection and, if switches or circuit breakers are used, it also provides control of circuits for light, heat or power. These circuits may be branch cir-



cuits or subfeeders. A panelboard is designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front.

Sizing Feeders

Feeders and subfeeders are sized to provide sufficient power to the circuits they supply. For the given circuit voltage, they must be capable of carrying the amount of current required by the load, plus any current which may be required in the future. Selection of the size of a feeder depends upon the size and nature of the known load computed from branch circuit data, the anticipated future load requirements and voltage drop. This represents one of the most important engineering tasks in electrical design work. Economy and efficiency of system operation and maintenance depend heavily on the selection of the proper size of feeders.

Experience with today's electrical modernization work has revealed feeder capacity as the big bottleneck in rewiring old buildings and even some that are not so old. In those buildings, the cost of bringing the capacity of the electrical systems up to meet modern load requirements would be considerably less if original design of feeders had been based on sound study of known and anticipated future loads. All of this experience confirms the importance of careful sizing of feeders, utilizing calculations related to the particular conditions of the job and not just a mechanical procedure of adding up load watts and dividing by volts to get required current-carrying capacity.

According to the code, feeders are sized to carry a computed load current which is not less than the sum of all branch circuit load currents supplied by each feeder, with certain qualifications:

1. For general illumination, a feeder must have capacity to carry the total load of lighting branch circuits determined as part of the lighting design or a minimum branch circuit load determined on a watts-per-square-foot basis from the table given in Section 2203 of the code. And these watts-per-square-foot values must be increased by 25% where branch circuit loads are to operate continuously for long periods of time—such as general lighting. The demand factors given in the last column of this table may be applied to the total branch circuit load to get required feeder capacity for lighting (but must never be used in providing branch circuit capacity).

2. If show-window lighting is supplied by the feeder, capacity must be included in the feeder to handle 200 watts for each linear foot of show-window length.

3. In single-family dwellings, in individual apartments of multi-family dwellings with provisions for cooking by tenants or in a hotel suite with a serving pantry, at least 1500 watts, to handle the small appliance load in kitchen, pantry, laundry and dining areas, must be added to the general lighting load on each feeder and may be subject to the demand factors given in the unit-load table.

4. In other than dwelling occupancies (where receptacle outlets of 15-amp or less are considered to be outlets for general lighting), the branch circuit load for receptacle outlets for which not more than 1½ amps were allowed per outlet may be added to the general lighting load, and may be subject to the demand factors.

5. Feeder capacity must be allowed for electric

Watts/Sq Ft Loads and Demand Factors for General Lighting Feeders

Type of Occupancy	COL. A Unit Load Per Sq Ft (Watts)	COL. B. Load to which Demand Factor Applies (Watts)	Demand Factor
Armories and Auditoriums	1	Total Wattage	100%
Banks	2	Total Wattage	100%
Barber Shops and Beauty Parlors	3	Total Wattage	100%
Churches	1	Total Wattage	100%
Clubs	2*	Total Wattage	100%
Court Rooms	2	Total Wattage	100%
Dwellings — (Other Than Hotels)	3*	3,000 or less	100%
		Next 117,000	35%
		Over 120,000	25%
Garages — Commercial (Storage)	½	Total Wattage	100%
Hospitals	2	50,000 or less	40%†
		Over 50,000	20%
Hotels, including apartment houses without provisions for cooking by tenants	2*	20,000 or less	50%†
		Next 80,000	40%
		Over 100,000	30%
Industrial Commercial (Loft) Buildings	2	Total Wattage	100%
Lodge Rooms	1½	Total Wattage	100%
Office Buildings	3	30,000 or less	100%
		Over 30,000	70%
Restaurants	2	Total Wattage	100%
Schools	3	Total Wattage	100%
Stores	3	Total Wattage	100%
Warehouses Storage	¼	12,500 or less	100%
		Over 12,500	50%
In any of above occupancies except single-family dwellings and individual apartments of multi-family dwellings:			
Assembly Halls and Auditoriums	1	Total Wattage as specified for the specific occupancy	
Halls, Corridors, Closets	½		
Storage spaces	¼		

†For subfeeders to areas in hospitals and hotels where entire lighting is likely to be used at one time, as in operating rooms, ballrooms, dining rooms, etc., a demand factor of 100% shall be used.

*Small Appliances. The small appliance load specified in subparagraph c-1, and the computed branch circuit load for receptacle outlets in other than dwelling occupancies, for which the allowance is not more than 1½ amps per outlet, may be included with the general lighting load and subject to the demand factors in paragraph a of this section.

NOTE:

The figures in this table are bare minimum, at 100% pf. No provision for load growth is made in these values.

cooking appliances rated over 1¾ kw, in accordance with Table 29 in Chapter 10 of the code. In most cases, the feeder must have a capacity of 8000 watts for a single electric range rated not over 12 kw. Feeder demand loads may be obtained from Table 29, Chapter 10 of the code.

6. For fixed appliances other than ranges and space heating equipment, feeder capacity must be provided for the sum of these loads and the total load of four or more such appliances may be reduced by a demand factor of 75%. (NEC, Sec. 2203e)

7. If motor loads are supplied by a feeder which also supplies lighting and appliance loads as described above, Article 430 of the code (Sections 4314, 4315 and 4316) gives the required capacity which the feeder must include to handle such loads. Feeder capacity for motor loads is usually taken at 125% of the full-load current rating of the largest motor supplied, plus the sum of the full-load currents of the other motors supplied.

8. Capacity of a feeder supplying fixed electrical space heating equipment is determined on the basis of a load equal to the total connected load on all branch circuits served from the feeder. Under conditions of intermittent operation or where all units cannot operate at the same time, permission may be granted for use of less than 100% demand factor in sizing the feeder.

From the total load represented by the foregoing particular loads, the required current-carrying capacity of feeder conductors is determined by dividing the total load in watts by the voltage between the hot leg and the neutral in the case of a 2-wire feeder, by the voltage between the two hot legs in the case of a 3-wire, single-phase feeder or by the square root of three, times the voltage between two phase legs in the case of 3-wire or 4-wire, 3-phase feeders from either a wye- or delta-connected source. If power factor is other than unity, it should be included in the denominator in all of these calculations. When the lighting and appliance load has been converted from watts (or volt-amperes) to a required current rating, the value of motor load current must be added to get the required current-carrying capacity of feeder conductors supplying a combination load of lighting, appliance and motor loads.

It should be noted that all of the foregoing are general requirements of the code and cover minimum load conditions. This is particularly true of the watts-per-square-foot unit loads given in the table, which are based on 100% power factor. And determination of feeder size solely on the basis of code requirements provides no relation to particular operating conditions in an occupancy, such as voltage stability and power losses, or any allowance for future growth in the load served by the feeder.

Although there are certain feeder applications which can be satisfactorily sized by use of the indicated code method of sizing, modern feeder design practice carefully incorporates such factors as voltage drop, power factor, detailed analysis of watts-per-square-foot loads, realistic and studied application of demand factors and provision of substantial spare capacity as required in each case.

Adding Branch Circuit Loads

In the section on "Branch Circuits," procedures were given for determining various types of branch circuit loads—general lighting, local lighting, fixed appliance, special receptacle circuits and general-use convenience receptacles—and for determining the number of circuits to handle the loads.

Whether general lighting circuits were determined on a watts-per-square-foot basis or from a lighting design layout, the amount of load for general illumination is known, and capacity for this load must be designed into the feeder, modified by the applicable demand factor from the table in Section 2203. Other circuit loads—such as local and/or special lighting, motor loads, electric cooking appliances and fixed appliances—are also gen-

erally known loads and can be accounted for in a feeder. Loads for convenience receptacle circuits and spare circuits in the panelboard, however, are not known and must be estimated in sizing a feeder.

From the known and estimated loads, the initial feeder load to a panelboard can be determined as follows:

1. For each multi-outlet branch circuit supplying general lighting, allow watts equal to the load on the circuit. If 50% loading of circuits is used, as recommended, allow 900 watts for each 2-wire, 120-volt 15-amp circuit; 1200 watts for each 2-wire,

Demand and Diversity—Important Definitions

Two terms constantly used in the literature of modern electrical design are *Demand Factor* and *Diversity Factor*. Because there is a very fine difference between the meanings for the words, the terms are often confused. The successful electrical designer, however, recognizes that these two expressions relate to separate and distinct characteristics of an electrical system. And he knows that consideration of these characteristics is essential to genuine economy, efficiency and effectiveness in design.

DEMAND FACTOR is the ratio of the maximum demand of a system, or part of a system, to the total connected load on the system, or part of the system, under consideration. This factor is always less than unity.

DIVERSITY FACTOR is the ratio of the sum of the individual maximum demands of the various subdivisions of a system, or part of a system, to the maximum demand of the whole system, or part of the system, under consideration. This factor generally varies between 1.00 and 2.00.

Another factor commonly used to analyze systems is . . . .

LOAD FACTOR, which is the ratio of the average load over a particular period of time to the peak load occurring in that period of time.

Demand factors and diversity factors are used in system design. For instance, the sum of the connected loads supplied by a feeder is multiplied by the demand factor to determine the load which the feeder must be sized to serve. This load is termed the maximum demand of the feeder. The sum of the maximum demand loads for a number of subfeeders divided by the diversity factor for the subfeeders will give the maximum demand load to be supplied by the feeder from which the subfeeders are derived.

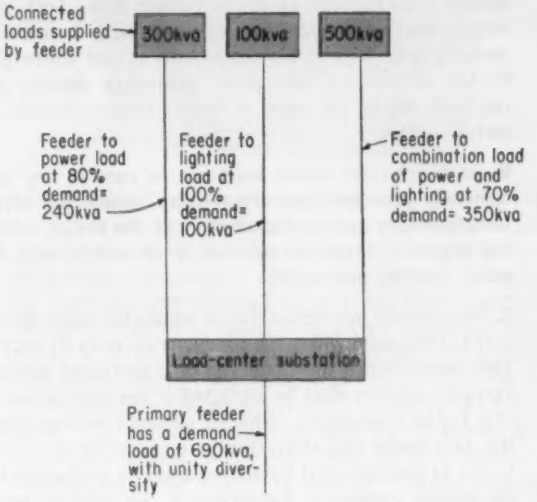
Tables of demand and diversity factors have been developed from experience with various types of load concentrations and various layouts of feeders and subfeeders supplying such loads. Article 220 of the NE Code gives a table of common demand factors for feeders to general lighting loads in various types of buildings. Typical values are given in this section.

It is common and preferred practice in modern electrical design to take unity as the diversity factor in main feeders to load center substations to provide a measure of spare capacity. Main secondary feeders are also commonly sized on the full value of the sum of the demand loads of the subfeeders supplied.

Load factors can be applied to system design when the sizes, duty cycles and other characteristics of connected feeder loads are well known. It is then possible to arrange operation of loads so that peak loads are satisfactorily supplied from a system of cables and transformers smaller than required by the peak. Such application is desirable only when the complete arrangement is carefully engineered, based on the heating-time curves of devices.

Typical Application of Demand and Diversity Factors To Part of Distribution System

(must not conflict with allowance for spare capacity)


Connected loads supplied by feeder
300kva
100kva
500kva
Feeder to power load at 80% demand= 240kva
Feeder to lighting load at 100% demand= 100kva
Feeder to combination load of power and lighting at 70% demand= 350kva
Load-center substation
Primary feeder has a demand load of 690kva, with unity diversity

1. Sum of individual demands = 240 + 100 + 350 = 690 kva
2. Sizing the substation at unity diversity, the required
$$\text{kva} = \frac{690}{1.00} = 690 \text{ kva}$$
3. To meet this load, use a 750-kva substation.
4. If analysis dictates the use of a diversity factor of 1.4, the required
$$\text{kva} = \frac{690}{1.40} = 492 \text{ kva}$$
5. To meet this load, use a 500-kva substation.
6. Primary feeder to unit substation must have capacity to match the substation load.

NOTE: **The kva-rating required for each of the secondary feeders must have a minimum value as described in the text of this section. And any feeder or subfeeder (even the primary feeder in this diagram) can be sized directly by summing connected loads, applying demand factors where necessary or desirable.**

Selection of Diversity Factors

From power distribution practice, basic diversity factors have been developed. These provide general indication of the way in which main feeders can be reduced in capacity below the sum of the demands of the subfeeders they supply.

On a radial feeder system, diversity of demands made by a number of transformers reduces the maximum load which the feeder must supply to some value less than the sum of the transformer loads.

Typical diversity factors for main feeders are as follows:

LIGHTING FEEDERS—1.10 to 1.50

POWER AND LIGHT FEEDERS—1.50 to 2.00 (or higher)

Selection of a diversity factor for any particular case must be based on study of load characteristics and operating cycles. Very accurate data on diversity of demands is recorded by operating personnel in many types of commercial and industrial buildings.

Overcurrent Protection for Conductors

GENERAL APPLICATION

A. Conductors in electric circuits must be protected against conditions of excessive current flow. Such protection must be provided in accordance with the current-carrying capacities of the conductors, except where particular settings or ratings of protective devices are required—as in the case of motor branch circuits or motor feeders.

B. An overcurrent device must not be used in any permanently grounded conductor—except where the device simultaneously opens all conductors of the circuit, where the electrical inspector requires it or where used for motor running protection.

C. Overcurrent protection for a conductor must be located at the point where the conductor receives its supply. This means that a conductor run of a particular current-carrying capacity must be protected at the point at which it is fed by a conductor of higher current-carrying capacity. In a feeder run, then, change in conductor size (from larger to smaller) must be accompanied by protection for the smaller conductor. Exceptions to this rule are made in the case of taps and where the protection for the larger conductor meets the requirements for protection of the smaller conductor.

SIZING PROTECTIVE DEVICES (not motor circuits)

A. If the allowable current-carrying capacity of a conductor does not correspond to the rating of a standard-size fuse, the next larger rating of fuse may be used—but the rating of the fuse must never exceed 150% of the allowable current-carrying capacity of the conductor.

B. Non-adjustable-trip circuit breakers must be rated in accordance with the current-carrying capacity of the conductors they protect—except that a higher-rated circuit breaker may be used if the carrying capacity of the conductor does not correspond to a standard unit rating. In such a case, the next higher standard rating and setting may be used if it is not in excess of 150% of the current rating of the conductor. Circuit breakers in the 0 to 30 amp sizes should be of the time-delay type.

C. Adjustable-trip circuit breakers of the thermal-trip, magnetic time-delay trip or instantaneous-trip types must be set to operate at not more than 150% of the allowable current-carrying capacity of the conductor.

120-volt 20-amp circuit; 1800 watts for each 2-wire, 120-volt 30-amp circuit; 2100 watts for each 2-wire, 277-volt 15-amp circuit; 2800 watts for each 2-wire, 277-volt 20-amp circuit; 4200 watts for each 2-wire, 277-volt 30-amp circuit.

2. For each multi-outlet plug receptacle branch circuit, allow watts equal to half the watts rating of the circuit, if such circuits were loaded to 50% of capacity, or allow watts equal to the load value of such circuits as used in branch circuit design. The minimum watts allowance for each receptacle circuit must equal the number of outlets times 1½ amps, times 120 volts.

3. For each multi-outlet branch circuit supplying heavy-duty lampholders, allow watts equal to the load on the circuit as used in branch circuit design. The minimum watts allowance for each heavy-duty circuit must equal the number of outlets times 5 amps, times the circuit volts.

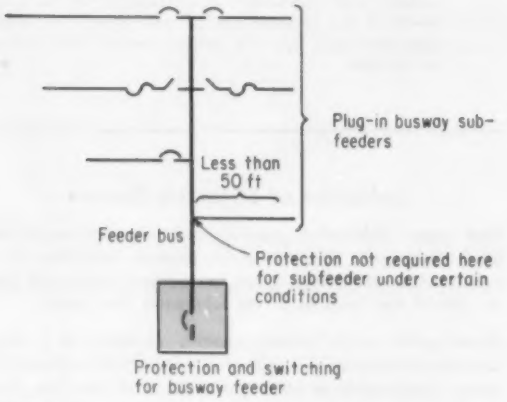
4. For each multi-outlet branch circuit supplying local or special lighting, allow watts equal to the load on the circuit.

5. For each individual branch circuit supplying a fixed appliance, allow watts equal to the rating of the appliance.

6. For each individual branch circuit supplying an electric cooking appliance, allow watts equal to the watts given in Table 29 in Chapter 10 of the code for the particular size of cooking appliance.

7. For each individual branch circuit supplying a motor, allow watts equal to 1.25 times the motor full-load current (from code Tables 21 to 24 according to the horsepower of the motor), times the circuit voltage. For 3-phase motors, the foregoing product must be multiplied by 1.732 to get the correct watts. Actually, the result of these calculations is not a watts value but a volt-ampere product, due to the lower-than-unity power factor of the motor. However, when sizing conductors to meet required load currents, the volt-ampere load should always be used for devices operating at less than unity pf, to assure required current capacity which is greater than would be required to supply only the watts—or effective power—represented by such loads.

Subfeed Protection in Busway System


Plug-in busway sub-feeders
Less than 50 ft
Feeder bus
Protection not required here for subfeeder under certain conditions
Protection and switching for busway feeder

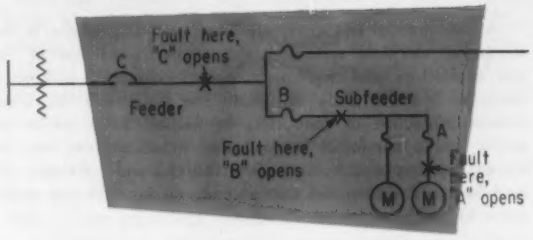
NOTE:
Overcurrent protection—either a fused-switch or circuit breaker—is usually required in each subfeeder tapping power from a busway feeder. This is necessary to protect the lower current-carrying capacity of the subfeeder and should be placed at the point at which the subfeeder connects into the feeder. However, the code provides that "Overcurrent protection may be omitted at points where busways are reduced in size, provided that the smaller busway does not extend more than 50 ft and has a current rating at least equal to one-third the rating or setting of the overcurrent device next back on the line . . ."

General Notes on Short-Circuit Protection

1. Under normal operation, a circuit draws current in proportion to the voltage applied and the impedance of the load. When a short circuit occurs, the source voltage no longer finds the normal opposition to current flow which the load presented. Instead, the voltage is applied across a very low impedance "load" made up of the impedance of the conductors from the source of voltage to the point of short-circuit fault, the impedance of the transformer from which the circuit is derived and any other impedances due to equipment interposed in the circuit between the transformer and the point of fault.

2. Overcurrent protective devices in circuits at all voltage levels must be capable of interrupting the maximum possible short-circuit currents delivered by the system into a solid short on their load terminals, without destroying themselves in the operation.

3. Coordinated selective protection for modern circuits provides fast, effective isolation of any faulted section of a system but does not interrupt service to any other section of the system. By careful study of time-current characteristics of protective devices, application can assure clearing of faults by the devices nearest to the faults on the supply side.



4. "Let-through" current is another factor in effective application of protective devices for short-circuits. A given protective device may be able to safely interrupt the maximum short-circuit current at its point of installation, but the time it takes to open the faulted circuit may be so long as to damage equipment or devices connected in series with the fault. Unless the device operates quickly enough, severe damage can be done due to the tremendous rupturing stresses created by short circuits. The system components must be related to the let-through current, which flows from the time the fault develops until the circuit is opened. Current-limiting fuses, for instance, open a short circuit in much less than a half cycle, thereby squelching let-through current.

---

8. For each branch circuit supplying more than one motor, allow watts equal to the following product: take 1.25 times the full-load current rating of the highest rated motor; add to this the sum of the full-load current ratings of the other motors; then multiply the total sum by the circuit volts. Again, this product must be multiplied by 1.732 to get the correct volt-ampere product for 3-phase motors.

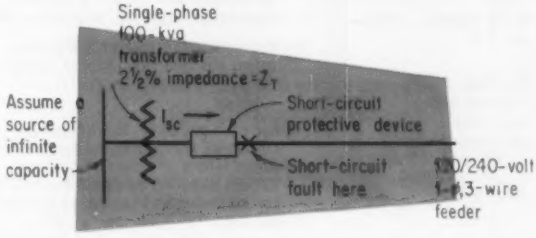
9. For each spare branch circuit provided in the panelboard, allow watts equal to the values given above for multi-outlet general lighting branch circuits (see foregoing par. 1).

Initial Feeder Capacity

By adding up these ratings, a total of watts is obtained which is the initial feeder load. Of course, the majority of feeders used in commercial, institutional and industrial buildings will serve only a few of the above described loads. And feeders in different buildings will handle different combinations of loads. Although the table in Section 2203 allows limited use of demand factors for general lighting circuits and multi-outlet plug receptacle circuits, reducing the feeder design load, most occupancies require a demand factor of 100% applied to the total load obtained by adding up the circuit loads.

The total load obtained above represents only the provision for initial branch circuit loads. Future utilization of the spare capacity designed into the branch circuits (they are loaded only to 50%) has not yet been accounted for in the feeder. And no provision has been designed into the feeder to meet the future possibility of exceeding the maximum capacity of the panelboard itself, requiring additional panelboard capacity—either a second panel or one new larger panel. Certainly, in the light of present experience with electrical modernization, there are many cases in which a little forethought and study would reveal the advisability of making such provisions in feeder capacity. Not in all cases, or even in most cases, but there is such a possibility; and only careful

Simple Calculation of Available Short-Circuit Current



Neglecting line and other impedances between the transformer and the fault—

Transformer full-load secondary current

$$= \frac{100{,}000 \text{ va}}{240 \text{ v}} = 417 \text{ amps}$$

Maximum short-circuit current based on transformer impedance

$$= \frac{100\%}{\%\, Z_T} \times \text{secondary full-load current}$$

$$\text{Max. } I_{sc} = \frac{100}{2.5} \times 417 = 16{,}680 \text{ amps}$$

The short-circuit protective device must be capable of safely interrupting this value of current. In a more rigorous analysis, this value would be reduced by all impedances in the circuit and would be affected by other considerations. Skill at detailed short-circuit analysis is essential to the modern design engineer.

Modern Design Demands Careful Application of Unprotected Feeder Taps

1. A fundamental but extremely important requirement in the design of electrical systems is the proper protection of circuit conductors and equipment against overload and fault currents. The NE Code sets forth the basic rule for overcurrent protection of conductors in Section 2403, which requires that a conductor be protected in accordance with its current-carrying capacity as given in Tables 1 and 2, Chapter 10. And Section 2434 requires that a conductor be protected at the point at which it receives its supply.

2. Although strict compliance with the above basic rules provides maximum protection against overloads and shorts and is always desired, field applications frequently make it impractical to fully meet code requirements. In certain cases, then, exceptions are made to meet practical requirements, with an attendant reduction in the degree of safety, which must be realized.

3. Exceptions to the rule for protecting conductors at their points of supply are made in the case of 10-foot and 25-foot taps from a feeder. The two tap exceptions are permitted as follows, without overcurrent protective devices at the point of supply:

TAPS NOT OVER 10 FEET LONG may be made from feeders provided—

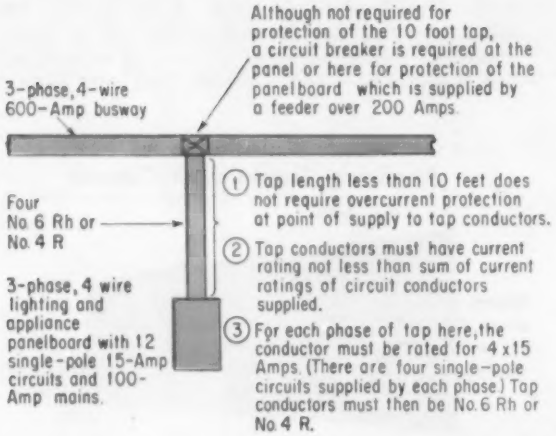
1. The smaller conductors have a current rating not less than the sum of the allowable current-carrying capacities for the conductors of the one or more circuits or loads supplied by the tap,
2. The tap does not extend beyond the switchboard, panelboard or control devices which it supplies, and
3. The tap conductors are enclosed in conduit, EMT or metal gutters when not a part of the switchboard or panelboard.

TAPS NOT OVER 25 FEET LONG may be made from feeders provided—

1. The smaller conductors have a current rating at least one-third that of the conductors from which they are tapped,
2. The tap conductors are suitably protected from mechanical damage, and
3. The tap is terminated in a single circuit breaker or set of fuses which will limit the load on the tap to its allowable current-carrying capacity.

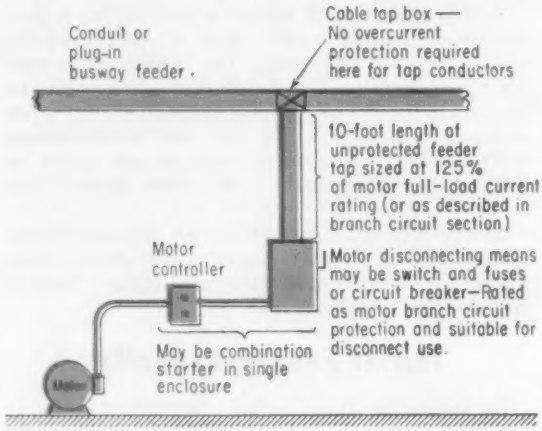
4. Application of the above tap exceptions should be made carefully, to effectively minimize any sacrifice in safety.

10-Ft Busway Tap to Lighting Panelboard With Unprotected Conductors

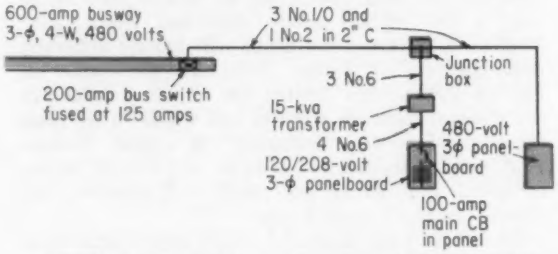

Although not required for protection of the 10 foot tap, a circuit breaker is required at the panel or here for protection of the panelboard which is supplied by a feeder over 200 Amps.
3-phase, 4-wire 600-Amp busway
Four No. 6 Rh or No. 4 R
3-phase, 4 wire lighting and appliance panelboard with 12 single-pole 15-Amp circuits and 100-Amp mains.
1 Tap length less than 10 feet does not require overcurrent protection at point of supply to tap conductors.
2 Tap conductors must have current rating not less than sum of current ratings of circuit conductors supplied.
3 For each phase of tap here, the conductor must be rated for 4 x 15 Amps. (There are four single-pole circuits supplied by each phase.) Tap conductors must then be No. 6 Rh or No. 4 R.

A common application of the 10-ft tap exception is the supply of panelboards from overhead conduit feeders or busways, as shown here. The case here shows an interesting requirement which arises from code Section 3883. This section requires that lighting and appliance panelboards which are supplied from conductors having overcurrent protection in excess of 200 amps must be protected on their supply side by overcurrent protection rated not more than the rating of the panelboard main. In the case here, this protection could be placed at the point of tap on the busway or could be a fused switch or circuit breaker main in the panelboard. Such protection could be rated up to the 100-amp main rating, but would be more economical if rated at 50 or 70 amps, inasmuch as this would provide more protection for the assembly without exceeding the total load. And it would probably be more desirable to place the panel protection in a busway plug-in device, thereby providing the necessary panel protection and also protecting the feeder tap.

Unprotected Busway Tap to Motor Circuit


Conduit or plug-in busway feeder
Cable tap box — No overcurrent protection required here for tap conductors
10-foot length of unprotected feeder tap sized at 125% of motor full-load current rating (or as described in branch circuit section)
Motor controller
Motor disconnecting means may be switch and fuses or circuit breaker—Rated as motor branch circuit protection and suitable for disconnect use.
May be combination starter in single enclosure

An Unusual Case of Unprotected Taps


600-amp busway 3-ϕ, 4-W, 480 volts
3 No. 1/0 and 1 No. 2 in 2" C
Junction box
3 No. 6
200-amp bus switch fused at 125 amps
15-kva transformer
4 No. 6
480-volt 3ϕ panelboard
120/208-volt 3-ϕ panelboard
100-amp main CB in panel

The main CB in the 120-volt panel is required by Sec. 3883-a because this is a lighting and appliance panelboard supplied by conductors having overcurrent protection in excess of 200 amps. The No. 6 conductors from the transformer to the panel are protected by only the 125-amp fuses in the bus switch. Through the transformer this acts as protection rated at 290 amps. The 100-amp CB protects the panel at its rating. The No. 6's are unprotected tap conductors. The CB also protects the transformer.

consideration of the nature of electrical utilization in a particular occupancy will accurately indicate possible future load requirements. But certainly in all cases of electrical design, some spare capacity must be provided in the feeders.

Allowance for load growth in feeders should begin with the spare capacity designed into the branch circuits. For all circuits loaded to 50% of capacity, it can be assumed that there is an allowance for growth of each circuit load by an amount equal to 30% of the circuit capacity.

This allowance is based on the code limitation of 80% load on circuits which are in operation for long periods of time or on circuits which supply motor-operated appliances in addition to other appliances and/or lighting. The 30% growth allowance in each circuit should be converted to total watts figure and added to the total load on the feeder as calculated above.

This grand total then represents the required feeder capacity to handle the full circuit load on the panelboard. The next step is to provide capacity in the feeder for anticipated load growth (plus some amount for possible unforeseen future requirements).

Spare Feeder Capacity

From experience, modern design practice dictates the sizing of feeders to allow increase of at least 50% in load on a feeder where analysis reveals any load growth possibilities.

Analysis of spare capacity allowances for feeders depends upon the type of building, the work performed, the plans or expectations of management with respect to expansion of facilities or growth of business, the type of distribution system used, locations of centers of loads, permanence of various load conditions and particular economic conditions.

Depending upon thorough study of all pertinent factors, the advisability of spare capacity can be determined for each feeder in a distribution system. But where study demands extra capacity in a feeder, substantial growth allowance—50%—is generally essential to realize the sought-after economy of future electrical expansion. Skimpy upsizing of feeder conductors or raceways has proved a major shortcoming of past electrical design work. This is particularly true in tall office buildings, apartment houses and other commercial buildings in which elimination of riser bottlenecks represents a large part of the total modernization cost.

Provision of spare capacity in feeders may be provided in one or more of several ways. If the anticipated increase in feeder load is to be made in the near future, the extra capacity should usually be included in the conductor size and installed as part of the initial electrical system. In many small office or commercial buildings and apartment houses, extra capacity should automatically be included in the initial size of the feeder conductors, provided the size is not greater than No. 2 after adding the 50% of extra capacity. Other methods of providing for growth in feeder load are as follows:

1. *Selection of raceways larger than required* by the initial size and number of feeder conductors. With this provision, the conductors can be replaced with larger sizes if required at a later date. The advisability of this step should be carefully considered in the case of risers or underground or concealed feeder raceway runs and similar cases of permanent installations where it will be impossible to add conduit runs at a later date. In some cases, a compromise can be made between providing spare capacity in the feeder conductor size and up-sizing the feeder raceway.

2. *Including spare raceways* in which conductors may be installed at a later date to obtain capacity for load growth. Such arrangements of multiple raceways must be carefully laid out and related to the existing overall system. The types of feeder distribution centers or main switchboards and the layouts of local branch circuit panelboards must be able to accommodate future expansion of distribution capacity based on the use of spare raceways, with modification and regrouping of feeder loads.

Selecting Conductor Sizes

When total design watts, including all of the foregoing provisions, have been determined, this

Calculating Current Which Feeder Conductors Must be Rated to Carry

$$I = \frac{\text{Load Watts}}{K \times E \times PF} = \frac{\text{Load Volt-Amperes}}{K \times E}$$

K = 1 for 2-wire dc or single-phase ac
= 1.73 for 3-wire, 3-phase ac
= 2 for 3-wire dc or single-phase ac
= 3 for 4-wire, 3-phase ac

E = voltage between outside wire and neutral or, if no neutral exists, between any two line wires (volts)

I = current in any line wire except neutral (amperes), which feeder must be rated to carry (check tables of conductor current ratings)

Calculating Power Loss in Circuit Conductors

Assuming resistivity of conductor metal to be as follows:

K = 12 for circuits loaded to more than 50% (copper)
K = 11 for circuits loaded to less than 50% (copper)
K = 18 for aluminum

For a 2-wire circuit (direct-current or single-phase):

$$P = \frac{2 \times K \times L \times I^2}{CM}$$

For a 3-wire, 3-phase circuit (assuming balanced load):

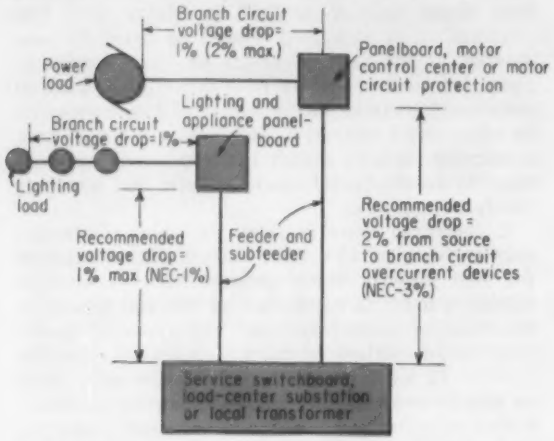
$$P = \frac{3 \times K \times L \times I^2}{CM}$$

In which, P = power lost in the circuit (watts)
K = resistivity of conductor metal (circular mil-ohms/foot)
I = current in each wire of the circuit (amperes)
L = one-way length of the circuit (feet)
CM = cross-section area of each of the wires in circular mils

When the resistance of conductors is determined from a table, the power loss is calculated from the relation

$$P = I^2R$$

Basic Limitations on Voltage Drop


Branch circuit voltage drop= 1% (2% max)
Power load
Panelboard, motor control center or motor circuit protection
Lighting and appliance panel-board
Branch circuit voltage drop=1%
Lighting load
Recommended voltage drop= 1% max (NEC-1%)
Feeder and subfeeder
Recommended voltage drop = 2% from source to branch circuit overcurrent devices (NEC-3%)
Service switchboard, load-center substation or local transformer

NOTES: 1. For combinations of lighting and power loads on feeders and branch circuits, use the voltage drop percentages for lighting load alone (at left above).

2. The word feeder here refers to the overall run of conductors carrying power from the source to the point of final branch circuit distribution, including feeders, subfeeders, sub-subfeeders, etc.

3. The voltage drop percentages are based on nominal circuit voltage at the source of each voltage level. Indicated limitations should be observed for each voltage level in the distribution system.

value is then used with the voltage and other electrical characteristics of the feeder (or the total load in amperes can be used) to obtain the required current-carrying capacity of the conductors. In addition to circuit voltage, feeder conductor size for a particular total load will depend upon the power factor and the voltage drop in the conductors.

An accompanying table covers the necessary calculations for sizing feeders. In these calculations, and in the determination of the feeder design load, care should be taken to distinguish between circuit load values in "watts" and those in "volt-amperes". When load values are in watts, power factor must be taken into consideration.

The size of conductors is related to total current values and must have capacity to carry the current at the given value of power factor. Of course, at low power factor, the conductors must have more current-carrying capacity to supply a particular load wattage than at high power factor.

Voltage drop must be carefully considered in sizing feeder conductors. According to the National Electrical Code, size of feeder conductors must be such that voltage drop up to the branch circuit panelboards or point of branch circuit origin is not more than 1% for lighting loads or combined lighting, heating and power loads and not more than 3% for power or heating loads. Local codes may impose lower limits of voltage drop. Design practice finds 1% for lighting loads and 2% for power loads as accepted voltage drop maximums.

Calculation of voltage drop in any set of feeders is described at the bottom of this page. From this calculation, it can be determined if the conductor size initially selected to handle the load will be adequate to maintain voltage drop within given limits. If it is not, the size of the conductors must be increased (or other steps taken where conductor reactance is not negligible) until the voltage drop is within prescribed limits.

Feeder Neutral Load

Section 2203-g of the code covers requirements for sizing the neutral conductor in a feeder. It states that "the neutral feeder load shall be the maximum unbalance" of the feeder load.

Basic Calculations for Voltage Drop

Two-Wire, Single-Phase Circuits: (Inductance Negligible)

$$V = \frac{2k \times L \times I}{d^2} = 2R \times L \times I \qquad d^2 = \frac{2k \times I \times L}{V}$$

V = drop in circuit voltage (volts)
R = resistance per foot of conductor (ohms/foot)
I = current in conductor (amperes)

Three-Wire, Single-Phase Circuits: (Inductance Negligible)

$$V = \frac{2k \times L \times I}{d^2}$$

V = drop between outside conductors (volts)
I = current in more heavily loaded outside conductor (amperes)

Three-Wire, Three-Phase Circuits: (Inductance Negligible)

$$V = \frac{2k \times I \times L}{d^2} \times 0.866$$

V = voltage drop of 3-phase circuit

Four-Wire, Three-Phase Balanced Circuits:

(Inductance Negligible):

For lighting loads: Voltage drop between one outside conductor and neutral equals one-half of drop calculated by formula for 2-wire circuits.

For motor loads: Voltage drop between any two outside conductors equals 0.866 times drop determined by formula for 2-wire circuits.

In above formulas—

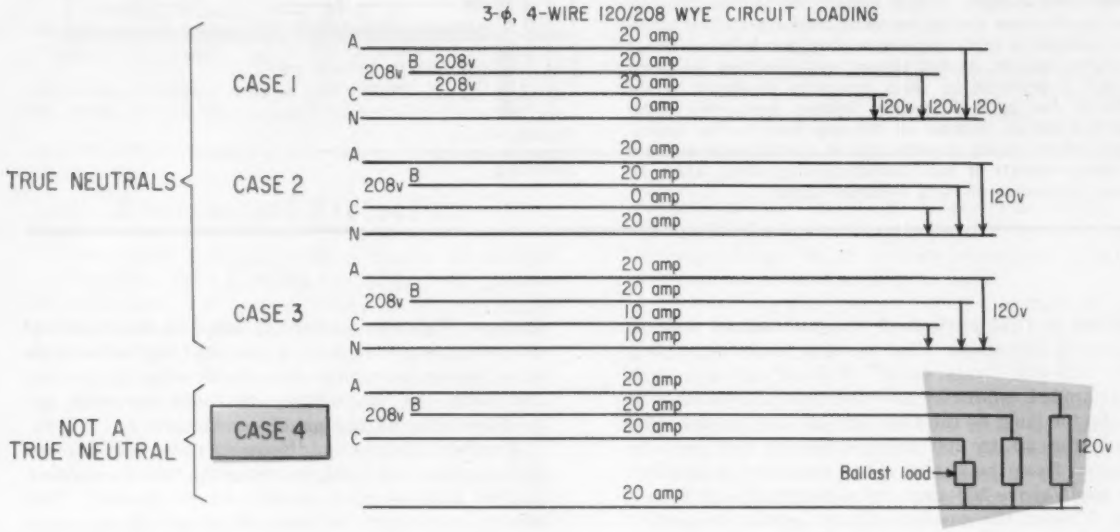
L = one-way length of circuit (feet)
d^2 = cross-section area of conductor (circular mils)
k = resistivity of conductor metal (cir mil-ohms/ft) (k = 12 for circuits loaded to more than 50% of allowable carrying capacity; k = 11 for circuits loaded less than 50%; k = 18 for aluminum conductor).

Neutral Loading Affects Conductor Derating for More-Than-Three Conductors in a Conduit

Size of a conduit required for a group of conductors depends upon the number and size of conductors. The basic code limitation on the number of conductors in conduit is given in Table 4, Chapter 10. This is based on groups of conductors of the same size and covers the general use of up to nine conductors per conduit.

When selecting the size of conduit, neutral conductors are included in the total number of conductors because they occupy space as well as phase conductors. A completely separate consideration, however is the relation of neutral conductors to the number of conductors which determines whether a derating factor must be applied to conductors in a conduit.

Note 5 following Tables 1 and 2 in Chapter 10 advises that a true neutral conductor—which carries only the unbalanced current from other conductors—shall not be counted in determining the current-carrying capacities of conductors in conduit as set forth in Note 4, preceding Note 5. This exclusion of the neutral when counting conductors for application of Note 4 is based on the heating characteristics due to loading of circuits with a neutral, as shown in the cases below:



Case 1—With balanced loads of equal power factor, there is no neutral current, and consequently no heating due to neutral. For purposes of heat derating according to Note 4, this circuit produces the heating effect of three conductors.

Case 2—With two phases loaded and the third unloaded, the neutral carries the same as the phases, but there is still the heating effect of only three conductors.

Case 3—With two phases fully loaded and the third phase partially loaded, the neutral carries the difference in current between the full phase value and the partial phase value, so that again there is the heating effect of only three full-load phases.

Case 4—With a balanced load of fluorescent ballasts, third harmonic generation causes a neutral current approximating phase current and there will be heating effect of four conductors. **Such a neutral conductor should be counted** with the phase conductors when determining conductor derating due to conduit occupancy.

"The maximum unbalanced load shall be the maximum connected load between the neutral and any one ungrounded conductor. . . ." In a 3-wire, 120-240-volt, single-phase feeder, the neutral must have a current-carrying capacity at least equal to the current drawn by the total 120-volt load connected between the more heavily loaded hot leg and the neutral.

It should be noted that straight 240-volt loads, connected between the two hot legs, do not place any load on the neutral. As a result, the neutral conductor of such a feeder must be sized to make up a 2-wire 120-volt circuit with the more heavily loaded hot leg. Actually, the 120-volt circuit loads on such a feeder would be considered as balanced on both sides of the neutral. The neutral, then, would be the same size as each of the hot legs if only 120-volt loads were supplied by the feeder. If 240-volt loads were also supplied, the hot legs would be sized for the total load, but the neutral would be sized for only half of the total 120-volt load.

Section 2203-g contains three other provisions for sizing neutral conductors. The first of these refers to electric range loads of feeders, the second refers to feeders of three or more wires and the third refers to neutral currents with balanced fluorescent ballast loads:

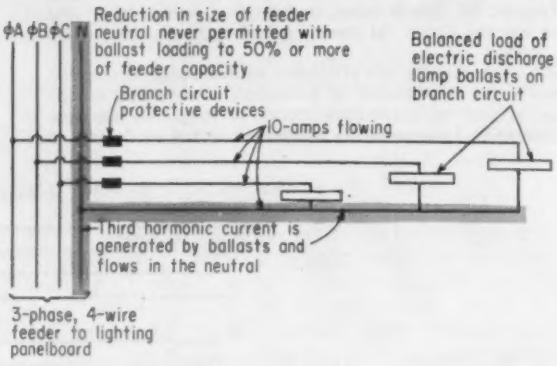
A. When a feeder supplies electric ranges, the neutral conductor may be smaller than the hot conductors but must have a carrying capacity at least equal to 70% of the current capacity required in the ungrounded conductors to handle the load. Table 29 in Chapter 10 of the code gives the demand loads to be used in sizing feeders which supply electric ranges and other cooking appliances.

B. For feeders of three or more conductors—3-wire, dc; 3-wire, single-phase; and 4-wire, 3-phase—a further demand factor of 70% may be

Full-Size Feeder Neutral for Supply to Branch Circuits Serving Electric Discharge Lamp Ballasts

In determining the neutral feeder load, the National Electrical Code permits the application of a 70% demand factor to that part of an unbalanced feeder load in excess of 200 amps. This reduces the size of the neutral conductor below the size of the phase conductors in feeders with a maximum unbalanced load of more than 200 amps. The maximum unbalanced load is defined as the maximum connected load between the neutral and any one ungrounded conductor.

But the code prohibits the use of this 70% demand when the feeder load consists of 50% or more of electric discharge lamp ballasts. In such feeders, the neutral conductor must be the same size as the phase conductors. This exception is based on tests which show that, in a balanced circuit supplying ballasts, neutral current approximating the phase current is produced by third harmonics developed by the ballasts. For large fluorescent lighting loads, this factor affects sizing of neutrals all the way back to the service. It also affects rating of conductors in conduit since a circuit as above consists of four current-carrying wires, which requires application of 80% reduction factor.


ϕA ϕB ϕC N
Reduction in size of feeder neutral never permitted with ballast loading to 50% or more of feeder capacity
Balanced load of electric discharge lamp ballasts on branch circuit
Branch circuit protective devices
10-amps flowing
Third harmonic current is generated by ballasts and flows in the neutral
3-phase, 4-wire feeder to lighting panelboard

applied to that portion of the unbalanced load in excess of 200 amps. That is, in a feeder supplying only 120-volt loads evenly divided between each ungrounded conductor and the neutral, the neutral conductor must be the same size as each ungrounded conductor up to 200 amps capacity, but may be reduced from the size of the ungrounded conductors for loads above 200 amps by adding to the 200 amps only 70% of the amount of load current above 200 amps in computing the size of the neutral. It should be noted that this 70% demand factor is applicable to the unbalanced load in excess of 200 amps and not simply to the total load, which in many cases may be made up of balanced 240-volt loads or straight 3-phase loads. Determination of required neutral current-carrying capacity can often be facilitated by vector analysis of the particular conditions involved.

C. In a feeder supplying ballasts for electric discharge lamps, when the conductors are loaded to 50% or more of their capacity, the neutral conductor must not be smaller than the phase conductors. This requirement is based on the empirical determination that, with a balanced load of ballasts on a feeder, harmonic currents flow in the neutral and that the magnitude of these currents approaches that of the phase conductors.

Another frequently discussed code requirement is that of Section 2204, covering the use of a common neutral with more than one set of feeders. This section says that "A common neutral feeder may be employed for two or three sets of 3-wire feeders, or two sets of 4-wire feeders. . . ." It further states that "When in metal enclosures, all conductors of feeder circuits employing a common neutral feeder shall be contained within the same enclosure. . . ."

A common neutral is a single neutral conductor used as the neutral for more than one set of feeder conductors. It must have current-carrying capacity equal to the sum of the neutral conductor capacities if an individual neutral conductor were used with each feeder set. A common neutral may be used only with feeders. It may never be used with branch circuits.

Motor Feeders

Article 430 of the code covers general requirements for motor feeders. Design of motor feeders must conform to these code requirements and must incorporate considerations of adequacy, flexibility, voltage drop and safety. Basic sizing and protection of feeder conductors involves the following procedures:

1. The current-carrying capacity of feeder conductors supplying several motors must at least be equal to 125% of the full-load current of the highest rated motor plus the sum of the full-load currents of the other motors supplied by the feeder.

2. The current-carrying capacity of feeder conductors supplying a single motor must at least be equal to 125% of the full-load current of the motor.

3. The current-carrying capacity of feeder conductors supplying a motor load and a lighting and/or appliance load must be sufficient to handle the lighting and/or appliance load as determined from the procedure for calculating size of lighting feeders, plus the motor load as determined from the previous paragraphs.

The code permits use of demand factors for motor feeders—based on reduced heating of conductors supplying motors operating intermittently or on duty-cycle or motors not operating together—when the authority enforcing the code deems the conditions and operating characteristics suitable for reduced capacity feeders. Application of such demand factors must be made carefully.

Engineered Sizing of Motor Feeders and Mains

Although the NEC allows sizing of motor feeders (and mains supplying combination power and lighting loads) on the basis of maximum demand running current, calculated as follows—

Running current = (1.25 × I_F) + (DF × I_T)
where, I_F = full-load current of largest motor
DF = demand factor
I_T = sum of full-load currents of all motors except largest

—modern design dictates use of the maximum demand starting current in sizing conductors for improved voltage stability on the feeder. This current is calculated as follows—

Starting current = I_S + (DF × I_T)
where, I_S = average starting current of largest motor (from Table 26 or 27, NEC)

Calculation of voltage drop in such circuits can be made on the basis of running current. Overcurrent protection for grounds and shorts is sized according to the starting current to permit starting of motors without operation of the protective devices. Maximum ratings or settings of overcurrent devices are set forth in Tables 26 and 27 of the NEC. Lower values may be used provided sufficient time delay is included in the protective devices to pass the starting current.

NOTES: 1. Sizing and overcurrent protection for any motor feeder must be engineered to meet the particular requirements of the load. Analysis must include: number of motors, sizes and types of motors, duty cycles, simultaneous starting of a number of motors, short-circuit load on conductors, time-current curves for protective devices and possible addition of loads.

2. Demand and diversity factors for motor feeders and mains must be carefully applied, with permission from the authority enforcing the code.

Overcurrent Protection

Overcurrent protection for a feeder to several motors must have a rating or setting not greater than the largest rating or setting of branch circuit protective device for any motor of the group plus the sum of the full-load currents of the other motors supplied by the feeder. If two or more motors of equal horsepower rating are the largest in the group, one of these should be considered as the largest for the calculation of feeder overcurrent protection. It should be noted that, in large capacity installations where extra feeder capacity is provided for load growth or future changes, the feeder overcurrent protection may be calculated on the basis of the rated current-carrying capacity of the feeder conductors.

In some cases, such as where two or more motors on a feeder may be started simultaneously, feeder conductors may have to be larger than usually required for feeders to several motors. In such cases, correspondingly larger ratings or settings of feeder overcurrent protection may be used.

In selecting the size of feeder overcurrent protective device, it should be noted that the NE code calculation is concerned with establishing a maximum value.

Protection for a feeder to both motor loads and a lighting and/or appliance load must be rated on the basis of both of these loads. The rating or setting of the overcurrent device must be sufficient to carry the lighting and/or appliance load plus the rating or setting of the motor branch circuit protective device if only one motor is supplied, or plus the highest rating or setting of branch circuit protective device for any one motor plus the sum of the full-load currents of the other motors, if more than one motor is supplied.

Typical Calculations for Conductor Size and Overcurrent Protection of Motor Feeders

Typical calculation of conductor size and overcurrent protection for a feeder serving a group of motors is shown here for the motor circuit example given in the Branch Circuit Section.

A feeder supplies four motors as follows:

1—50 hp-squirrel cage induction motor (full-voltage starting)
1—30 hp-wound-rotor induction motor
2—10 hp-squirrel-cage induction motors (full-voltage starting)

The feeder is a 3-phase, 440-volt, 60-cycle supply.

From Table 24 of the code, the motors have full-load current ratings as follows:

50-hp motor = 63 amps—which requires No. 3 R or No. 4 RH branch circuit conductors.

30 hp motor = 39 amps—which requires No. 6 R or No 6 RH branch circuit conductors.

10-hp motor = 14 amps—which requires No. 12 R or No. 12 RH branch circuit conductors.

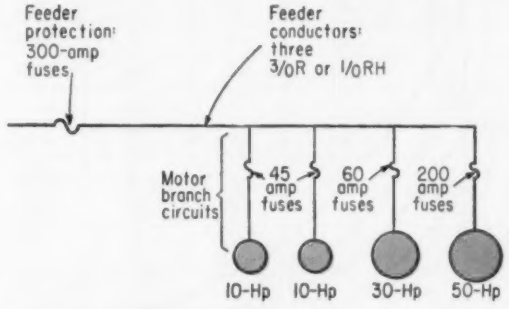
The feeder conductors must have a carrying capacity as follows:

1.25 × 63 = 79 amps + 39 amps + (2 × 14 amps) = 146 amps

The feeder conductors must then be No. 3/0 R or No. 1/0 RH

OVERCURRENT PROTECTION (From Code Table 20)

1. The 50-hp motor must be protected at not more than 200 amps (fuse) for branch circuit protection.
2. The 30-hp motor must be protected at nor more than 60 amps (fuse) for branch circuit protection.
3. Each 10-hp motor must be protected at not more than 45 amps (fuse) for branch circuit protection.



FEEDER OVERCURRENT PROTECTION

The maximum rating or setting for the overcurrent device protecting such a feeder must not be greater than the largest rating or setting of branch circuit protective device for one of the motors of the group plus the sum of the full-load currents of the other motors. From the above, then, the maximum allowable size of feeder fuses is—

200 + 39 + 14 + 14 = 267 amps, or 300-amp fuses

NOTE: The values obtained by these calculations are minimum basic sizes and ratings required for the given load. Use of circuit breaker protection would involve other calculations. And voltage drop and line losses would also have to be considered. Overall layout and choice of equipment could also affect ultimate sizings.

Feeder Voltage Drop and Current Capacities for 600-Volt, Type RH Conductors

VOLTAGE DROP AND CAPACITIES

60 cycle—3-phase in steel conduit (49°C temp.)
Reference: Standard Hndbk. Elect. Engrs.

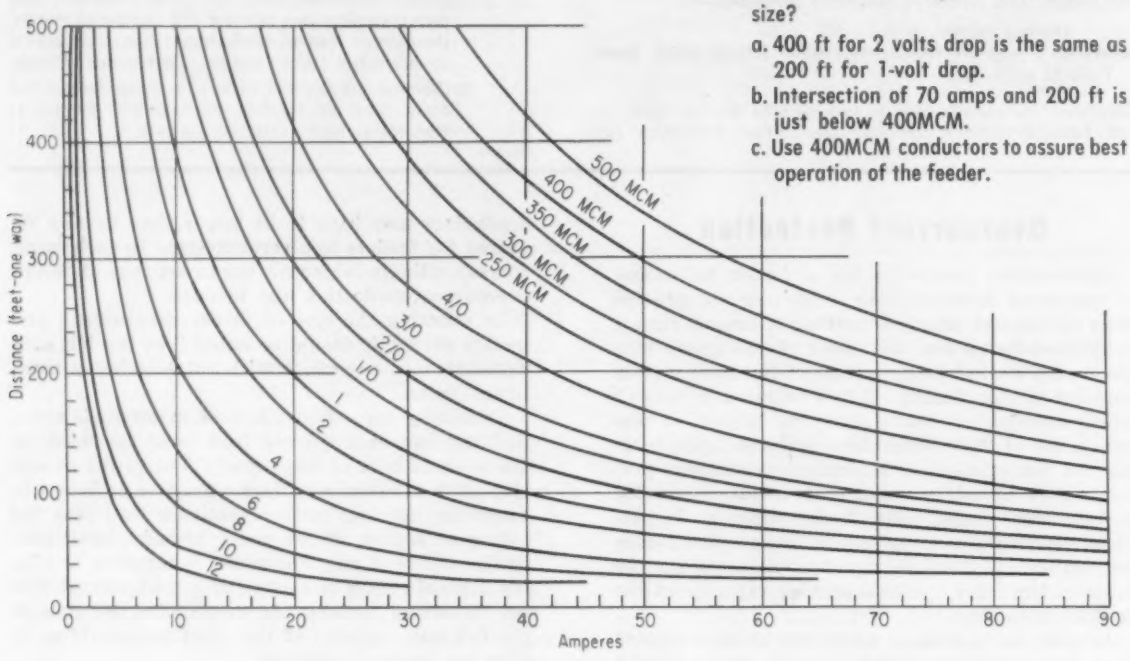
GENERAL NOTES

Curves are for a 1-volt drop and 90% PF
For any other voltage drop, ratio ordinates.
Capacities are for Type RH 600-volt insulation.

TYPICAL EXAMPLE

Required: to carry 70 amps 400 ft with a maximum of 2 volts drop, what is the wire size?

a. 400 ft for 2 volts drop is the same as 200 ft for 1-volt drop.
b. Intersection of 70 amps and 200 ft is just below 400MCM.
c. Use 400MCM conductors to assure best operation of the feeder.

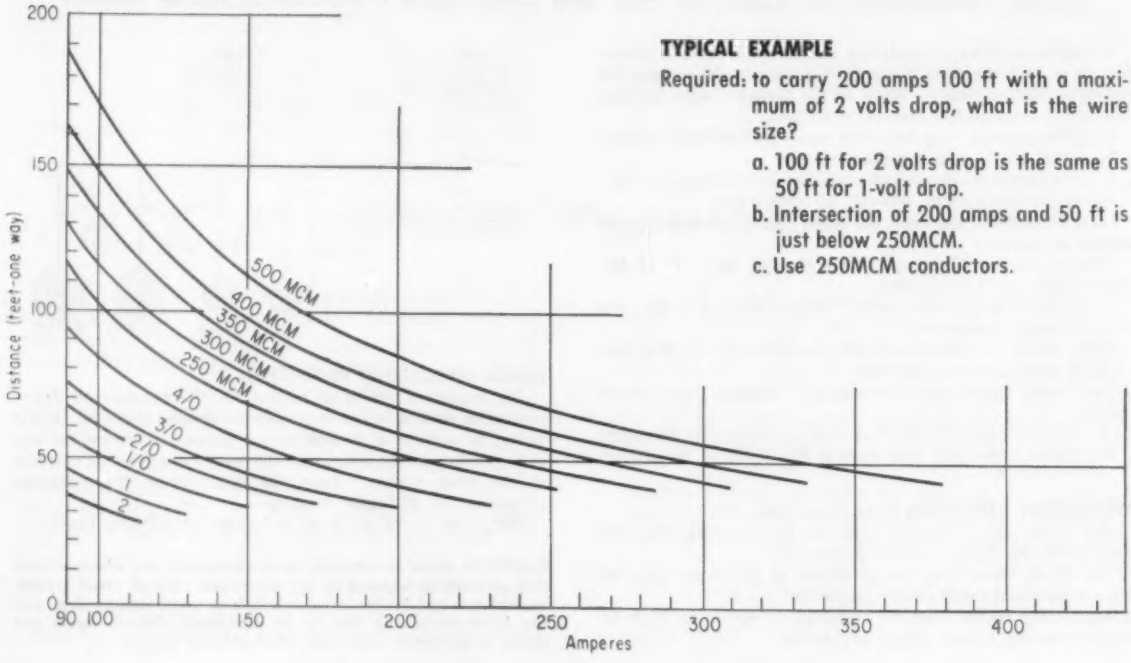


(Curves continued from above)

TYPICAL EXAMPLE

Required: to carry 200 amps 100 ft with a maximum of 2 volts drop, what is the wire size?

a. 100 ft for 2 volts drop is the same as 50 ft for 1-volt drop.
b. Intersection of 200 amps and 50 ft is just below 250MCM.
c. Use 250MCM conductors.



Voltage Drop

Voltage drop and copper loss must be carefully taken into consideration when sizing motor feeders. The design percentage of tolerable voltage drop may vary with the particular operating conditions and layout of the motor loads served but must never exceed 3% drop from the service entrance to the point of origin of motor branch circuits. However, a maximum voltage drop of only 2% from the service to points of motor branch circuit protection is widely used for motor feeder design.

Calculation of voltage drop should include consideration of reactance as well as resistance in the feeder conductors, as both contribute to the drop. Power factor must also be accounted for in these calculations. And voltage drop in a feeder must also be analyzed in terms of the number of motors supplied, the size of each motor and the operating duty.

When a number of motors might be starting simultaneously or several motors driving sluggish loads might be started at or near the same time, the voltage drop in the feeder could be extreme unless its size accounted for the high load current. Of course, such conditions and analysis of them will often clearly indicate further sub-division or adjustment of feeder loads, selection of types of motors to use and selection of the best types of controllers to use. The initial value of starting current—the locked-rotor current—must be used in studying the effect of motor loads on voltage drop.

Calculating Power-Factor of Motor Feeder

The power factor of a circuit supplying several motors is determined as follows:

1. For each motor, multiply its horsepower by its power factor at 75% of rated load.
2. Add up these products for all of the motors.
3. The sum obtained in "2" divided by the total horsepower connected to the circuit will give the approximate (but accurate enough for most calculations) power factor of the circuit.

Copper loss in motor feeders—the watts lost in the conductors due to heat developed by current flow through the conductors—equals the square of the total current drawn through the conductors times the total resistance of the conductors. This loss may frequently be substantial even when the voltage drop in the feeder is within recommended limits.

All voltage drop studies and calculations should include consideration of further increasing conductor size—over that necessary to limit voltage drop—in order to limit copper loss. Power factor is related to these matters.

Table of Design Data Used to Determine Required Capacitor PF Correction For Plug-In Busway to Motor Loads

Bus duct	Total hp	40% Demand	95% Eff.	Kw	Kva 80%	Kvar 80%	Kva 95%	Kvar 95%	Kvar diff.	Kvar use
1A	364	146	153	109	136	82	115	35	47	45
1B	374	150	157	117	142	85	124	38.4	46.6	45
1C	461	185	194	145	181	109	153	47	106	105
2A	735	(30%) 220	230	172	215	130	181	56	74	75
2B	1300	(30%) 390	410	306	382	230	322	100	130	135
3A	729	291	307	229	183	110	218	67	43	45
3B	275	110	116	87	69	41.5	83	25.6	16	15
3C	532	213	225	168	134	80	160	49.5	30.5	30
3D	356	143	151	113	90	54	108	33.4	20.6	30
4A	532	213	225	168	134	80	160	49.5	30.5	30
4B	520	208	219	163	130	78	155	48	30	30
4C	320	128	135	100	80	48	95	29.4	18.6	30

Busways in a modern industrial plant are used to supply plug-in circuits to motor loads as indicated. Total hp of connected motor load was determined for each busway run. A demand factor was applied based on past experience and metering, reducing the demand on the busway run. The hp ratings were then corrected for the efficiency of the motors, assuming 95%. This new total hp value was converted to kw. A corresponding kva value was established for 80% power factor. Reactive kva values were also determined. The kva and kvar values were established for the given kw values, based on an assumed power factor of 95%. The differences in kvar were then noted for each busway to establish the required amount of kvar for each busway to bring its power factor up to about 95%. Based on the use of 15-kvar unit capacitors, rated at 575 volts for the twelve sections of 600-amp, 480-volt, 3-phase, 4-wire busway, the total value of capacitor equipment for each busway is shown in the last column. Capacitor equipment was then mounted on the busway sections.

Switchboards and Panelboards

In modern buildings, feeder distribution centers provide for protection and control of feeders to various loads. In 3-phase, 4-wire systems, both lighting and power feeders may originate from a single distribution center. In those systems using separate power and light services, a separate distribution center is generally used with each type of feeder.

Modern distribution centers for lighting and appliance feeders include dead-front panelboards and dead-front switchboards. Feeders are tapped through fused switches or circuit breakers from the buses in such distribution centers.

Distribution centers are usually supplied by the service conductors to buildings and contain the main service switches. This is the most common arrangement in commercial and institutional buildings. In many industrial buildings, feeder distribution centers may be supplied from transformers which step high-voltage distribution to utilization levels.

Selection Factors

Selection of suitable panelboards and/or switchboards for feeder distribution is based on many factors. Manufacturers of such equipment offer a wealth of literature and technical data on the characteristics and application advantages of the different types.

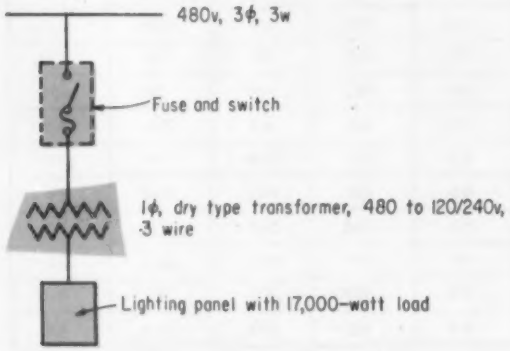
In selecting feeder disconnect and protection equipment, consideration should be given to spare capacity in this equipment. Depending upon the anticipated future requirements and the manner in which extra capacity was included in the feeders, space should be provided in switchboards and/or feeder panelboards for additional switches or circuit breakers or for future installation of larger switching and protection units. And design of the distribution system must integrate all provisions for future expansion of feeder capacities. This includes the routing of spare feeder conduit, accessibility to feeder raceway in which capacity has been allowed for increase in feeder conductors, ease of connections in the switching and protection assemblies.

Construction of modern switchboards and feeder panelboards will accommodate all of these design provisions for load growth. Care in the selection of the proper type of switching and protection assemblies—with buses of substantial capacity for future expansion of the system—is essential to economy of distribution design.

Modern commercial, institutional and industrial buildings generally utilize dead-front switchgear of sectional construction. The assembly may contain fused switches in safety-type unit enclosures or unit circuit breakers.

Selection of switchgear will depend upon voltage rating, ampere rating, number of phases and short-circuit rating. Circuit-breaker switchgear may be of the stationary type, in which the breakers are bolted to the bus and frame, or of the draw-out type, in which the breakers are mounted on a slide-out mechanism for easy removal or maintenance, disconnecting the breaker from the bus. Switchboards may be equipped with provisions for instrument transformers and metering. Feeders from the switchboard may be carried directly to lighting or power branch circuit panelboards, to subfeeder distribution switchboards or panelboards, to motor

Typical Step-by-Step Calculations for a Feeder Circuit



1. On the basis of 15-amp branch circuits, and for continuous operation of the load, we can have as much as 0.8 x 15 x 120 or 1440 watts per circuit. The panel will have to contain at least 17,000/1440 or 12 circuits.

2. For the 17,000-watt connected load operating at 100% demand, the minimum capacity of secondary conductors will have to be 17,000/240 or 70 amps. Three No. 4 Type R or RH in 1¼-in. conduit are required.

3. The main buses of the lighting panelboard must have at least 70-amp capacity.

4. The smallest standard size transformer to be used here is 25 kva. Under some conditions, it might be possible to use a 15-kva transformer operated overloaded during peak hours.

5. On the basis of the 17,000-watt load, the primary current would be 17,000/480 or 35 amps. Two No. 8 Type R or RH in ¾-in. conduit could be used.

6. The transformer overcurrent protective device could be rated as high as 250% of the rated primary current. The rated primary current for this transformer is 25,000/480 or 52 amps. The transformer then can be protected by any protective device set or rated for not more than 2.5×52 or 130 amps.

7. But the protection used ahead of the transformer must also protect the primary circuit conductors to the transformer and the secondary conductors to the panel. Maximum protection for the No. 8's must be set at no more than 40 or 50 amps, depending upon type of insulation (R or RH). But a primary fuse set at more than 35 amps would not protect the secondary No. 4's with Type R insulation. Type RH No. 4's, however, rated at 85 amps would be protected by primary fuses rated up to 40 amps. Careful application of protection in such circuits is always required.

Step-by-Step Calculations for a Combination Load

The following is a calculation procedure, based on the NE code, for sizing circuit elements to supply a load of—

A. Four 3-phase, 220-volt, squirrel-cage induction motors, designed for 40C temperature rise, marked Code letter H, started across the line and rated:
one—10-hp motor,
one—7½-hp motor and
two—1½-hp motors; plus

B. A 20-kw, single-phase 115-volt lighting load.

Step 1.—Average full load currents (Table 24)
10 hp—27 amps
7½ hp—22
1½ hp— 5

Step 2.—Main feeder for motors (Section 4314)
10: 1.25 x 27 or 33.75 amps
7½: 22
1½: 2 x 5 10
Total 65.75 amps
3 No. 6 RH (Table 1) in 1-in. conduit (Table 4)

Step 3.—Individual branch circuits for each motor (Sec. 4312)
10: 1.25 x 27 or 33.75 amps
3 No. 8 RH (Table 1)
¾-in conduit (Table 4)
7½: 1.25 x 22 or 27.5 amps
3 No. 10 RH in ¾-in.
1½: 1.25 x 5 or 6¼ amps
3 No. 14 RH in ½-in.

Step 4.—Motor overcurrent protection (running protection usually thermal relays, heaters, etc in controller, Section 4322). Since the same 125% factor applies for this as it does for the individual branch circuit size calculation, the maximum rated thermal elements, etc, shall be for each
10 hp: 33.75 amps
7½ hp: 27.5
1½ hp: 6.25

Step 5.—Maximum rating of branch circuit overcurrent protection. Table 26 (also see Section 4342) shows for these motors and Code letter H a maximum of 300% for fuse rating, therefore for
10 hp: 27 x 3 or 81 amps—use 100-amp block with three 90-amp fuses
7½: 22 x 3 or 66 amps—use 100-amp block with three 70-amp fuses
1½: 5 x 3 or 15 amps—use 30-amp block with three 15-amp fuses

Step 6.—Main motor feeder protection (Section 4362)
10 hp: 27 x 3 or 81 (or 90) amps.
7½: 22
1½: 2 x 5 or 10
113 (or 122) amps.
Use 200-amp switch with three 125-amp fuses.

Step 7.—The following pertains to the lighting load. Assume this to be 115/230 single phase. The full-load current would be

$$\frac{20 \times 1000}{230} \text{ or } 87 \text{ amps}$$

Use 100-amp switch with two 90-amp fuses.
Use three No. 3 RH in 1¼-in. conduit.

Step 8.—If these two loads will be fed from separate services then the above calculations are complete. If a combination service is to be used, since many utility companies like to feed each customer with a single service and thus have a single meter, then we can serve this customer with a 4-wire, 240-volt, delta service. This is obtained by increasing the size of one of the transformers in the delta bank to take care of the single phase load also, and using the center tap of this larger transformer for the neutral for the lighting load. The lighting load is thus fed only from two phases of the three phases.

Step 9.—Motor feeder 113 amps (starting demand)
Lighting (2 phases) 87
200 amps

The main switch would be a 200-amp size with two 200-amp fuses in two phases and one 125-amp fuse in the third phase.

Two main service lines would be 3/0 RH, one would be No. 6 RH and the neutral would be No. 3 RH.

---

control centers or to individual motor loads.

Feeder distribution panelboards are also made in many sizes and types, with either fuse or circuit breaker protection for the feeders or subfeeders originating in them. Such panelboards are generally used as the main feeder distribution center in small and medium sized commercial and institutional buildings and in some small industrial occupancies. In many cases, this panelboard will contain the service disconnect and protection.

Motor feeders may be carried to a motor control center, to a power panelboard, to a subfeeder switchboard or panel or to individual motor branch circuits tapped from the feeder. Motor subfeeders may be carried to a motor control center, to a power panelboard or to individual motor branch circuits.

A power panelboard is a fused-switch, circuit breaker or fuse panelboard from which motor branch circuits originate. It may only provide protection for the branch circuit conductors; but in most cases, the power panel also provides disconnect means for each motor load.

A motor control center is a dead-front assembly of cubicles, each of which contains branch-circuit overcurrent protection, motor disconnect means, motor controller and motor running overcurrent protection. It is a type of switchboard which contains all the protective and control means for the motors supplied from it.

Selection and application of power panels and motor control centers should be related to future requirements. Such units must have necessary spare capacity in their buses and must be adapted to whatever change or expansion is anticipated. Lay-

Multiple-Conductor Makeup of High-Capacity Feeders

From the code tables of current-carrying capacities of various sizes of conductors, it can be seen that small conductor sizes carry more current per circular mil of cross section than do large conductors. This results from rating conductor capacity according to temperature rise. The larger a cable, the less is the radiating surface per circular mil of cross section. Loss due to "skin effect" (apparent higher resistance of conductors to alternating current than to direct current) is also higher in the larger conductor sizes. And larger conductors cost more per ampere than smaller conductors.

All of the foregoing factors point to the advisability of using a number of smaller conductors in multiple to get a particular carrying capacity, rather than using a single conductor of that capacity. In many cases, multiple conductors for feeders provide distinct operating advantages and are more economical than the equivalent-capacity single-conductor makeup of a feeder.

The following circuit makeups represent typical considerations in the application of multiple conductor feeders:

1.

A 3-phase circuit of three 2000 MCM type R conductors in a 6-in. conduit.
Current rating of each phase = 560 amps.
Cross-section area per phase = 3.2079 sq. in.

2.

A 3-phase circuit of six 400 MCM type R conductors (two per phase) in a 4-in. conduit.
Current rating of each phase might appear to be = 2 × 280 = 560 amps.
But, because of the 80% derating required by Note 4 to Table 1 in Chapter 10 of the NEC.
Current rating of each phase = 560 × 80% = 448 amps.
Cross-section area per phase = 1.6730 sq in. (two conductors).

3.

A 3-phase circuit of three 1000 MCM type R conductors in a 4-in. conduit.
Current rating of each phase = 455 amps.
Cross-section area per phase = 1.7531 sq in.

4.

A 3-phase circuit of six 600 MCM type R conductors in a 5-in. conduit.
Current rating of each phase might appear to be = 2 × 355 = 710 amps.
But 80% derating must be applied because of the number of conductors in the conduit.
Current rating of each phase = 710 × 80% = 568 amps.
Cross-section area per phase = 2.3880 sq in. (two conductors).

NOTES:

a. Without derating for conduit occupancy, circuit 2 would be equivalent to circuit 1.
b. A circuit of six 400 MCM's can be made equivalent in current-carrying capacity to a circuit of three 2000 MCM's by dividing the 400's between two conduits (3 conductors/3" conduit).
c. Circuit 2 is almost equivalent to circuit 3 in current rating.
d. Circuit 4 is equivalent to circuit 1 in current rating, but uses less conductor copper and a smaller conduit. And the advantages are obtained even with the occupancy derating.

out of power panels and motor control centers should be related to voltage drop and the lengths of feeders versus branch circuits to motors.

Laying Out Motor Feeders

Layout of motor distribution systems will depend upon the type of building, construction characteristics of the building and the number, sizes and types of motors to be served:

A. Miscellaneous motor loads in the majority of commercial and institutional buildings and in many industrial buildings are usually circuited from power panels to which feeders deliver power. This type of distribution is a standard method of motor circuiting, generally limited to handling a number of motors of small integral horsepower or fractional horsepower sizes, located in a relatively small area such as a fan room or pump room.

The feeder to a power panel may be a riser in a multi-story commercial or institutional building, run from a basement switchboard. In a one-level industrial area, the feeder to a power panel may be run from a main or load-center switchboard or from a load-center substation in a high voltage distribution system. In commercial and industrial buildings, motor feeders may be run from a main switchboard or a load-center substation to a motor control center serving a large group of motors in a machine room or in any compact area where the motors are relatively close together and close to the control center assembly.

B. In industrial buildings, where a large number of motors are used over a large area, distribution of power to the individual motor loads generally follows the method of tapping motor branch circuits from the feeder. As was indicated in the discussion of "Branch Circuits", tapping a feeder to motor branch circuits may be done in several ways, by providing various combinations of branch circuit over-current protection and motor control and disconnect means.

The feeder in such a circuit-tapping arrangement may originate from a main switchboard or from a load-center substation. In multi-story buildings, such as office buildings or institutions, taps to motor branch circuits on a particular floor may be taken from a subfeeder originating in a loadcenter switchboard which is fed by a riser from the main switchboard in the basement.

The feeder-tap method of supplying motor branch circuits is, of course, the basis for plug-in busway distribution to spread-out motor loads. In the system, the plug-in busway may be a feeder or subfeeder depending upon its origin. From a main switchboard, it would be a feeder. From a load-center switchboard, it would be a subfeeder. However, from a load-center substation, the plug-in busway would be a feeder—a secondary feeder derived from the transformation down from the primary feeder to the substation.

Generally, layout of motor feeders should be as direct as possible to minimize voltage drop and power losses due to I^2R losses in the conductors. Inductive reactance drop should also be checked in high capacity feeders. The use of multiple conductors for the makeup of high current feeders can reduce both the amount of wire and raceway used.

Load-Center Substations

Design of electrical systems for modern industrial plants varies widely with the nature of the activity. However, electrical distribution within all industrial occupancies has the same general objective—to get required power to load devices as economically and efficiently as possible.

Design of a distribution system to meet requirements of any plant or area is greatly affected by such considerations as: the importance of power continuity and the relation of power outages to production or processing operations; economy of installation and operating costs; the flexibility requirements of the particular type of industrial activity; safety and protection of personnel and equipment.

Depending upon the conditions and requirements in any particular case, design of an industrial distribution system may incorporate modern methods such as load-center distribution from unit substations, high-voltage distribution to substations and alternative supply lines to each substation. The load-center substation is the key to this modern industrial distribution.

In the layout of load-center distribution, load-center unit substations are located in the approximate center of the area occupied by the load devices supplied from the substation. Of course, the exact location of a substation with respect to the equipment it supplies depends upon the number and relative sizes of the load devices and the construction characteristics of the building. The number of unit substations required in any installation will depend upon the total load to be served and the capacities of the individual unit substations.

Each unit substation is fed by high-voltage (2400 volts to 13,800 volts) incoming power lines, transforms the power down to low voltage (under 600 volts) and supplies feeders to motors and other power loads and feeders to lighting loads, either directly—for 277-volt lighting—or indirectly through step-down transformers for 120-volt circuits.

The use of load-center substations allows efficient and economical distribution of large bulks of power throughout a plant. Distributing power at high voltages requires much lower feeder current-carrying capacities than would be required to distribute the same amount of power at low voltage. As a result, the primary feeders are relatively small in size and not subject to the severe voltage drop conditions which result from the use of long, low-voltage but high-current feeders to load concentrations. And the locations of the unit substations, in the center of each load concentration, permit the use of very short secondary feeders or branch circuits to loads, again minimizing voltage drop and copper loss.

Many advantages may be realized through the use of load-center distribution in industrial plants. It has been estimated that the savings in feeder copper alone may run as high as 20%. And other substantial savings are effected through elimination of much heavy-capacity secondary switchgear.

In addition to initial economy, load-center distribution provides unusual flexibility and adaptability to expansion of facilities at a later date, offering long range economies. The installation and connection of unit subs into a system is a relatively simple and easy matter, following manufacturer's instructions and minimizing special engineering.

Design Procedure

Design of a load-center distribution system for any industrial plant begins with analysis and breakdown of the total load within the building. From this study, the number and sizes of load center subs will be determined.

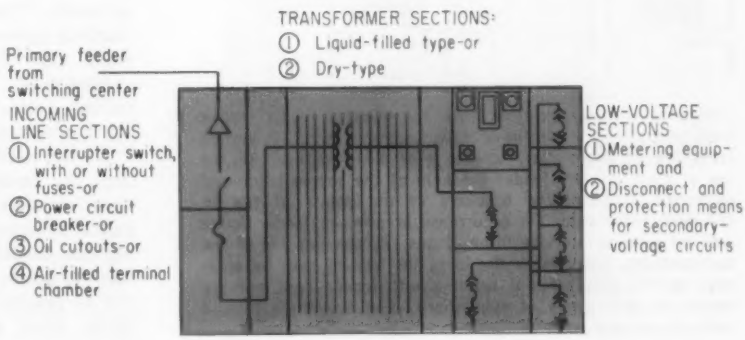
In general, the total load in the plant is broken into blocks and apportioned among a number of unit substations. The number of unit subs selected for any installation must take into account certain facts of economy involved in equipment application. Typical considerations include the following:

a. Generally, the smaller the unit sub, the more expensive it is per kva.

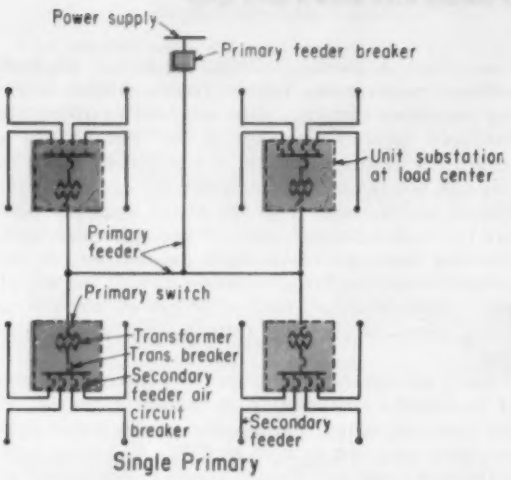
b. The greater the number of unit subs, the greater the amount of primary cables.

Basic Elements of a Typical Load-Center Substation

The most common arrangement for the incoming line section of modern load-center substations consists of a high-voltage load interrupter switch, with suitable power fuses for protection of the substation. In a typical case, the primary feeder to the substation might originate in a metalclad CB switchgear center. In some cases, where the primary feeder switchgear is located near the unit sub and no other sub is fed by the feeder, additional protection and switching is not required in the incoming line section of the substation and an air-filled terminal chamber can satisfy incoming line requirements. Where fuses cannot be coordinated for primary transformer protection, a power circuit breaker is required.

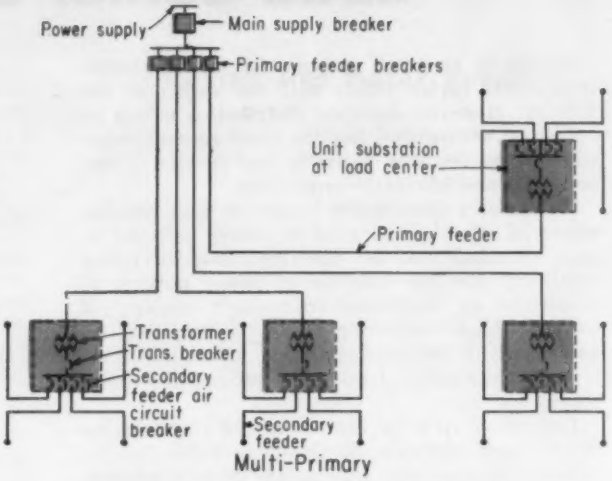


Two Primary Circuit Layouts for Radial, Load-Center Distribution



Single Primary

Basic radial system for high-voltage distribution with load-center substations. Used where the total system load to be served exceeds several hundred kilowatts and where the use of a single substation or secondary voltage service would result in long heavy feeders with characteristic high cost, poor voltage regulation and low efficiency. Offers advantages of high voltage distribution at lowest cost.



Multi-Primary

A variation on the basic system; has individual primary feeders to unit subs. Provides more flexible system. Reduces the effect of outages due to fault on primary feeder in basic system. Use of automatic protective devices in each primary feeder increases cost of system over basic system. Adaptability to load growth and plant changes is improved over that of the basic system using a single prmiary feeder.

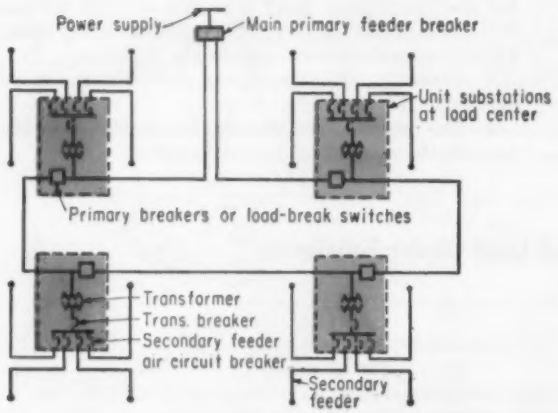
c. But the use of a large number of unit subs, each covering only a small area of load accumulation, reduces the lengths of secondary feeders.

d. The use of a small number of very large subs, however, requires less primary conductors but more secondary conductors.

From investigation of standard kva ratings of unit subs and system costs per kva, it has been found that economy usually dictates the use of unit subs rated from 500 to 1500 kva. Maximum economies, however, can be realized from the use of substations rated from 750 to 1000 kva.

A typical load-center substation contains high-voltage switchgear in an incoming section, a transformer section in which the power is stepped to low voltage and a section containing switching and protection for the outgoing secondary feeders. High-voltage switchgear may utilize circuit breakers or interrupting switches with or without power fuses. A number of oil-filled or dry-type transformers are used in unit subs, offering advantages for indoor and outdoor applications. Secondary switching and protection usually consists of completely enclosed assemblies of drawout type circuit breakers.

Radial System With Loop Primary



Similar to the basic system, with the primary feeder looped back on itself at the point of power supply. Increases system reliability at slight cost increase over basic system. By the use of main primary feeder breakers at the source point and automatic sectionalizing breakers at the points of tap to the load-center subs, the occurrence of primary feeder faults will not interrupt service to any loads. By opening one of the sectionalizing breakers in the loop, the system may be operated as two simple radial systems with independent primary feeder to each group of substations. The system is then a form of primary selective system.

Layout of Substations

One of the most important considerations in the use of load-center substations is the layout or circuiting arrangement used. Typical systems are: radial, secondary selective, primary selective and network. The accompanying illustrations cover the various systems with remarks on the application of each. Further information on the particular advantages of the different system circuits can be obtained from manufacturers' literature and from their application engineers.

Of the load-center distribution systems in use today, the great majority follow a simple radial pattern or secondary selective layout. The simple radial system offers a high order of reliability and service continuity and is safe, flexible, stable and easy to operate and maintain. Where more flexibility is required, use of two unit subs with a normally open secondary tie breaker between them

forms a secondary selective system. A double-ended substation, with primary supply to each end and a normally open secondary tie within the assembly, may also be used to form a secondary selective system.

In operation, each substation or each end of a double-ended sub operates as a straight radial system. If one primary feeder or transformer should fail or be taken out of service, the load normally carried on that substation or that end of a double-ended substation is automatically transferred to the still-operating substation.

The secondary selective system represents a cost increase of only 5% to 15% over a simple radial system. It is widely used in manufacturing and processing plants of all types.

Typical configurations of selective circuiting techniques are shown in the diagrams below.

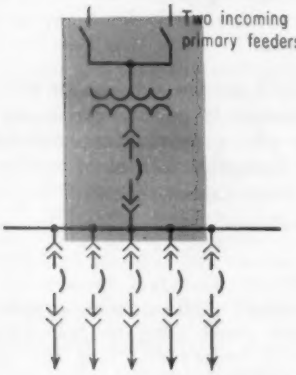
Primary Voltage

Selection of the primary voltage to be used with a load-center distribution depends upon the available utility lines, the total load to be supplied and the number of unit subs to be used. Consultation with the local utility is essential to selection of the best primary voltage.

Primary distribution at 13.8 kv usually offers the best load-center design at lowest cost for very large industrial plants with demand load above 20,000 kva. Between 10,000 kva and 20,000 kva, plant load may be economically served by either 13.8-kv or 4160-volt primaries. For plants with demands below 10,000 kva, primary distribution at 4160 volts is generally recommended.

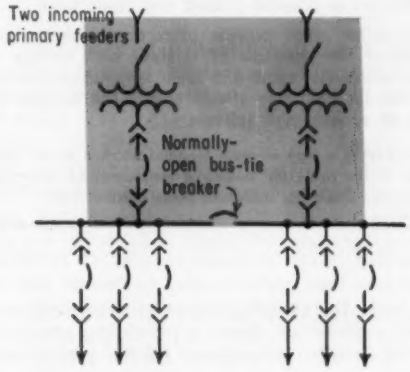
Although 2400-volt primary distribution is applicable to load-center distribution, the use of 4160

Typical Selective Concepts for Substation Layouts



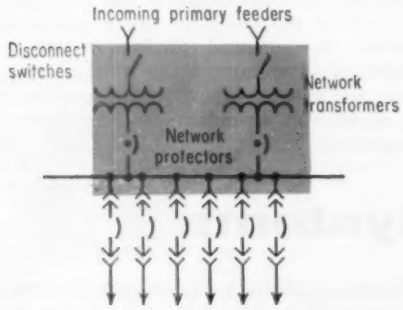
PRIMARY SELECTIVE

Primary-selective radial system provides choice of primary feeder for improved service reliability in the event of primary feeder fault. Transfer means is provided to assure rapid reconnection from one primary to the other.



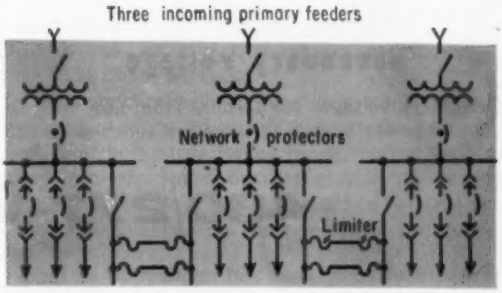
SECONDARY SELECTIVE

Secondary-selective radial system provides separate operation of transformers and secondary bus in normal operation. Upon primary or transformer fault, interlocked breakers are arranged to serve total secondary from one transformer.



SPOT NETWORK

Two or three transformers are connected to a common secondary bus and divide the load. Upon primary or transformer fault, secondary is isolated from the faulted section by automatic operation of the network protector, providing high order of supply continuity in the event of faults.



GENERAL NETWORK

The general form of the network system is similar to that at left, except that individual substations are used with associated network protectors and tie circuits between the secondary bus sections. System provides for interchange of power to accommodate unequal loading on the transformers.

Notes on Cable Terminations for High Voltage Feeders

1. Paper-insulated cables must be terminated in potheads.* This requirement also extends to such cables operated under 600 volts.
2. Varnished-cambric cables should be terminated in potheads, but may be terminated with taped connections in dry locations (or under 600 volts).
3. Rubber-insulated cables are commonly terminated in potheads, but may be terminated without potheads in accordance with manufacturer's instructions.
4. Although many modern high voltage cables can be terminated without potheads, many engineers consider potheads the best termination for any high voltage cable.
5. The use of potheads for cable connections to equipment offers a number of advantages—
   A. Seals cable ends against moisture which would damage the insulation,
   B. Provides a compartment for surrounding the termination with insulating compound to increase strength of electrical insulation,
   C. Seals cable ends against loss of insulating oils, and
   D. Provides engineered support and connections.
6. Stress relief cones provide protection against insulation failure at the terminals of shielded high voltage cables. Manufacturers of cable and cable terminators provide special kits for preparing stress relief cones for cables operating at various high voltages.

*A POTHEAD is a type of cable terminal which provides sealing to the sheath of the cable for making a moisture-proof connection between the wires within the cable and those outside.

Switching and Overcurrent Protection in Primary Distribution Systems

Switching and short-circuit overcurrent protection for modern high-voltage circuits—2,300 to 15,000 volts—can be provided by:

1. **Metalclad oilless (air type) circuit breaker switchgear,**
2. **Metalclad load interrupter switchgear with power fuses, and/or**
3. **Oil-fuse cutouts**

POWER CIRCUIT BREAKERS provide load switching, short-circuit protection, electrical operation, adjustable tripping for coordinated protection schemes, quick reclosing after tripping and differential relay protection for transformers.

MODERN LOAD-INTERRUPTER SWITCHGEAR can match the ratings and performance capabilities of power circuit breakers, with the exception of quick reclosing and relay protection, providing substantial overall economies in many primary applications. Quick reclosing and relay protection for transformers are not generally sufficiently important to warrant higher first cost of CB equipment. Conventional or current-limiting fuses may be used with interrupter switches.

OIL-FUSE CUTOUTS provide switching or switching and short-circuit protection in primary circuits up to 8 kv, 300 amps. They offer economical application for transformer primary protection, such as in load-center substations, in the lower capacity circuits.

volts instead offers economy in cost of switchgear and requires less feeder copper to handle the same kva of load. Interrupting capacities are higher for 4160-volt switchgear, thereby providing greater expansion possibilities without future requirements for limiting fault currents.

The code places a limitation on the use of high voltage within a building. Up to 15,000-volt lines may be carried through a building. When utility voltage is below 15 kv, the primary lines may be brought into the plant and carried directly to the unit substations, with no need for intermediate voltage transformation between the service entrance and the subs. If, however, the utility voltage is above 15 kv, a voltage step-down is required before power lines can enter the building.

Secondary Voltage

Secondary voltages for feeders from unit subs to light and power branch circuits are selected on the basis of the amount and types of load devices.

Usually, 480-volt secondary feeders are used to handle motor loads, with minimum copper requirements. In such cases, dry-type transformers are fed by 480-volt feeders and step the voltage to single-phase 120/240 volts, or 120/208 volts, 3-phase, for lighting, plug receptacles and other miscellaneous loads. Use of 277-volt lighting for high-bay and general applications in industrial areas is derived directly from 480/277-volt secondary feeders.

In very few cases, such as where considerably less than half of the total load is power, 120/208-volt, 3-phase, 4-wire distribution may be derived directly from the secondaries of unit subs and carried throughout the building. Such application is rare and not recommended. Savings in copper, better regulation of voltage, lower voltage drop and line losses and greater capacity for expansion favor the use of 480-volt secondary distribution in load-center systems.

480/277-Volt Systems

Widespread acceptance and application of industrial high voltage systems has stimulated the use of higher voltages in electrical systems for commercial and institutional buildings. Not too many years ago, 3-wire, single-phase 120/240-volt distribution systems and 3-phase, 4-wire 120/208-volt distribution systems were standards for non-industrial buildings. Today, although these lower voltage systems still find wide and efficient application, the 480Y/277-volt, 3-phase, 4-wire system is established as the preferred secondary-voltage system for use where substantial motor loads and general-area fluorescent lighting must be supplied, such as industrial and large commercial buildings.

The growth of electrical loads in commercial buildings was responsible for the development of the 480Y system which has many characteristics similar to industrial type systems. Air conditioning

Fundamentals of Overcurrent Protection for Transformers

The code requires overcurrent protection for each transformer or bank of transformers operating as a unit. Protection shall be provided as follows:

1. **An overcurrent protective device—rated or set at not more than 250% of the rated primary current—must be placed in the primary connection of each transformer. Such protection, however, is not required if the overcurrent device protecting the primary circuit is rated or set at not more than 250% of the rated primary current.**

2. **A transformer is not required to have an individual overcurrent device in the primary connection if it has an overcurrent device—rated or set at not more than 250% of the rated secondary current—in the secondary connection, or if it is equipped with an integral thermal overload protector. In such a case, the primary feeder overcurrent device must have a rating or setting at not more than six times the rated current of the transformer for transformers having not more than 6% impedance, and not more than four times the rated current of the transformer for transformers having more than six but not more than 10% impedance.**

In completely packaged, metal-clad unit substations, the transformer protection is provided as an integral part of the assembly. The switchgear and all other elements are matched to each other in accordance with the kva rating of the substation.

Dry-type and other distribution transformers must be provided with proper overcurrent protection as part of the electrical design work. The provisions of Article 450 of the code and manufacturers' instructions and engineering literature should be consulted and carefully followed.

Individual dry-type transformers of the general-purpose type —used for local mounting to serve 120-volt lighting and receptacle loads in 480-volt distribution systems—are generally protected on the primary side by either a remotely operated fuse-switch combination or a circuit breaker. The secondary side feeds directly into the branch circuit panelboard. Such transformers are generally mounted close to the center of the load they serve, require a minimum of maintenance, keep distribution losses to a minimum, eliminate the need for separate low-voltage power circuits and improve voltage regulation. They are available in ratings from 1 kva to about 500 kva.

---

loads and business and other machine loads increased the ratio of power to lighting loads, calling for the type of circuit treatments and layouts which industrial plants use to economically and efficiently serve heavy motor loads.

Higher-voltage feeders to motor loads and to stepdown transformers for lighting and receptacle circuits proved the ideal solution. Less copper is needed to distribute the heavy power requirements, and voltage drop and other losses are effectively minimized. And the development of extensive lines of lighting equipment which operates on 277-volt circuits has contributed greatly to the widespread success of this system.

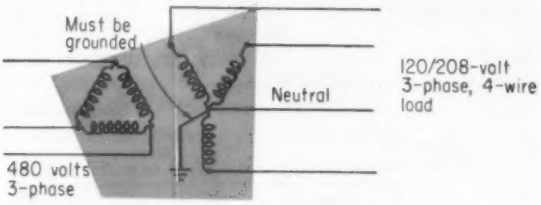
From studies made, it has been found that a typical 480Y system can provide savings of more than $25 per kva demand over a 120/208-volt system to handle the same load. Many installations over the

Effective Grounding Techniques for Dry-Type Transformers in 480/277 Systems

With the growing popularity of distribution systems using transformer load centers, particularly the 480/277-volt system, effective grounding of transformer secondaries is an important consideration. The elements of this design matter are as follows:

1. Any system which operates at not more than 150 volts to ground must be grounded.

2. This requires the grounding of secondaries of dry-type transformers serving 120/208-volt, 3-phase or 120/240-volt, single-phase circuits for lighting and appliance outlets and receptacles, at load centers throughout a building.

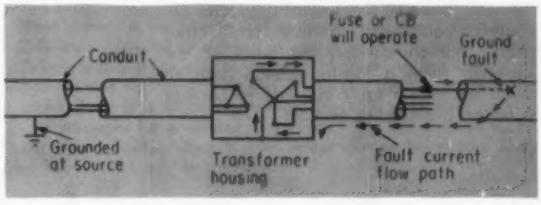


3. All code rules applying to both system and equipment grounding must be satisfied in such installations.

4. Grounding of the secondary neutral may be made to the nearest water pipe anywhere in the building, provided bonding jumpers are used to assure continuity of the ground path wherever the piping may be opened. (See NEC Sec. 2582)

5. According to Section 2554, when a system (in this case, the electrically isolated circuits from the transformer secondary) is grounded to an electrode in a building, the same electrode must be used at the same point to provide ground connection for wire enclosures and other housings, frames, enclosures, etc., even though the equipment may be grounded already through the conduit system supplying the transformer. By connecting the system neutral and the transformer frame to the same point, the ground return path for fault currents on the secondary circuits is kept short to have low enough impedance and sufficient current-carrying capacity to handle any fault currents and to assure operation of the overcurrent devices protecting the circuits, as required by Section 2551 of the NE Code.

6. Common practice with dry-type local transformers in many installations is to merely connect the secondary neutral point to the transformer frame, leaving the feeder conduit to the transformer to provide the path to ground but depending upon the connection between neutral and frame to provide effective return for clearing faults.



Fundamentals of Grounding for Electrical Circuits

Requirements

All interior alternating-current wiring systems must be grounded if they can be so grounded that the maximum voltage to ground does not exceed 150 volts. Where the maximum voltage to ground would be above 150 volts but not over 300 volts, it is recommended that ac systems be grounded. Higher voltage ac systems may be grounded, but the code does not require or recommend it.

Direct-current systems—both 2-wire and 3-wire—must also be grounded if the voltage to ground will not exceed 300 volts. A 2-wire dc system, with no more than 300 volts between conductors, must be grounded unless it is used for supplying industrial equipment in limited areas and is equipped with a ground detector. In a 3-wire dc system, the neutral conductor must be grounded.

Article 250 of the NE code presents detailed requirements on grounding of electrical circuits and equipment.

Recommendations

Grounded neutral systems are generally recommended for high-voltage distribution. Although ungrounded systems do not undergo a power outage with only one-phase ground faults, the time and money spent in tracing faults indicated by ground detectors and other disadvantages of ungrounded systems have consistently favored the use of grounded neutral systems. Grounded systems are more economical in operation and maintenance. In such a system, if a fault occurs, it is isolated immediately and automatically.

Grounded neutral systems have many other advantages. The elimination of multiple faults caused by undetected restriking grounds greatly increases service reliability. The lower voltage to ground which results from grounding the neutral offers greater safety for personnel and requires lower equipment voltage ratings. And on high-voltage (above 600) systems, residual relays can be used to detect ground faults before they become phase-to-phase faults which have substantial destructive ability.

---

past years—in schools, office buildings, industrial plants, shopping centers and sports arenas—have convincingly proved the economic and operating advantages of the 480/277-volt system.

System Techniques

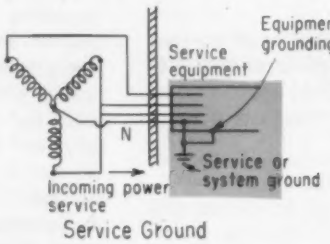
The 480Y system was developed to meet the requirements of prevailing commercial building load conditions.

In general, most general lighting is fluorescent and can be served by 277-volt circuits. Motors for air conditioning compressors, circulating fans, elevators and pumps make up an average load of about 4 volt-amperes per square foot. These motors can be more efficiently and economically supplied at 480 than at lower voltages, and they are less expensive than lower voltage motors of the same hp ratings. The combined power and general lighting loads average between 4 and 10 watts per square foot. Receptacle and miscellaneous loads—desk lamps, local lights, business machines, appliances, water coolers, etc.—average only about ½ to 2 watts per square foot.

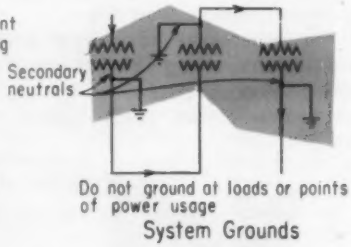
As can be seen from the above, about 80% of a building load may be served directly by 480-volt feeders. Provision of 120-volt circuits may be made either by using separate 120/208-volt substations or by using the previously mentioned 480- to 120-240-volt dry-type transformers installed locally at the center of each concentration of 120-volt loads. The latter method offers greater economy, even when the amount of 120-volt loading is as high as 5 watts per square foot.

Types of Grounding

A SERVICE OR SYSTEM ground is the intentional grounding of one conductor of the system to limit the maximum potential to ground due to normal operating voltage and to limit the voltage on the system due to lightning or other abnormal conditions. The neutral point of the transformer(s) or generator(s) is usually the point connected to ground.

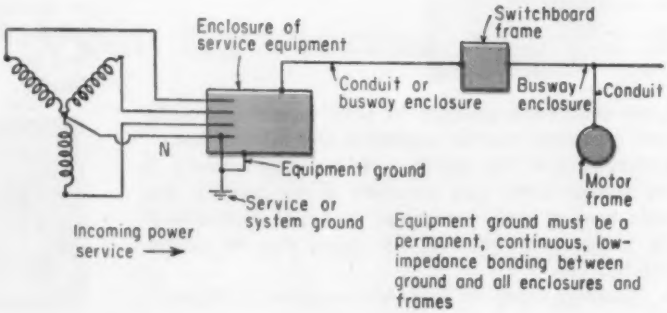


Service Ground



System Grounds

AN EQUIPMENT ground is a permanent and continuous bonding together of conductor enclosures, equipment frames and other metallic non-current-carrying parts of the system to form a low-impedance path to ground to enable fault currents to operate the system overcurrent devices.



Notes on Equipment Ground in Grounded Systems

1. In modern grounded wye systems, the equipment grounding network includes conduit, motor and transformer frames, junction and pull boxes, busway enclosures, etc. It should be a continuous and permanent bonding together of all conductor enclosures, equipment frames and housings and other non-current-carrying parts of the system.

2. The equipment ground is very important, and its impedance must be sufficiently low to assure operation of overcurrent protective devices.

3. In a grounded system with a high-impedance equipment ground return system, a ground fault may not cause enough current flow to open the circuit, thereby placing a hazardous voltage on the equipment enclosures and establishing conditions for some very serious accidents. As in the case of a phase ground on an ungrounded system, a phase-to-phase fault must develop to operate the overcurrent device, with all of the attendant hazards of such conditions.

4. For effective protection against common ground faults, therefore, low impedance of the equipment bonding system is more important than low impedance of the earth ground itself. And in long runs of magnetic material conductor enclosures, the ground circuit impedance should be taken as 10 times the dc resistance to allow for the many variables.

5. In large-capacity systems, especially low-voltage (120 volts) and high-current (1000 amps and up), grounding can be made more effective by using red lead on all joints in major conduit runs.

Wiring Systems

Although busway and interlocked armor cable are constantly gaining feeder applications in all kinds of buildings, conduit and cable feeders are still the most widely used in commercial, institutional and industrial buildings.

The number of conductors permitted in a particular size of conduit is covered in the code, in Tables 4, 5 and 9 for conductors all of the same size and in Table 11 for a combination of conductors of different sizes. For non-lead covered conductors, four or more to a conduit, the sum of the cross-sectional areas of the individual conductors must not exceed 40% of the interior cross-sectional area of the conduit or tubing.

To fill conduit to the code allowance is a minimum practice and frequently difficult or impossible from the mechanical standpoint of pulling the conductors into the conduit, due to twisting or bending of the conductors within the conduit. Bigger-than-minimum conduit should generally be used to provide some measure of spare capacity for load growth, and in many cases, the conduit to be used should be up-sized considerably to allow future installation of some larger, anticipated size of conductors.

Conduit Occupancy

When sizing feeder conductors on the basis of the loads to be served, the voltage drop to be expected and the computed amount of spare capacity, the derating factors applicable to conductors in conduit must be applied:

According to Note 4 following Tables I and 2, "Table 1 gives the allowable current-carrying capacity for not more than three conductors in a raceway or cable. If the number of conductors in a raceway or cable is from seven to nine, the allowable current-carrying capacity of each conductor shall be reduced to 70% of the values in Table 1." The code makes exception to derating requirements

Cable Selection for Primary and Secondary Feeders

CONDUCTOR SIZE is determined according to—

A. load current to be supplied,
B. voltage drop and regulation,
C. temperature rise within the limitations of the insulation,
D. reasonable energy losses, and
E. ability to withstand short-circuit heating.

INSULATION must be selected according to—

For voltage up to 600:

A. cost,
B. temperature rise, including both ambient temperature and temperature due to heating effect of load,
C. ease of installation,
D. environment in application, such as moisture, fumes, chemicals, petroleum products, acids, alkalies, etc.;

For high voltage (over 600 volts)

A. tested and proved physical and electrical characteristics.

PROTECTIVE COVERING must be selected according to—

A. excellence of protection for the insulation against environment (moisture, chemicals, acids, etc.),
B. excellence of protection against physical damage, such as abrasion, impact, cutting, etc., and
C. ability of any metallic coverings to withstand corrosion and electrolysis.

NOTE: A very important consideration, indicated above, is the provision of conductor size to meet the potential heating load of short-circuit currents in cables. With expanded use of circuit breaker overcurrent protection, coordination of protection from loads back to the source has introduced time delays in operation of overcurrent devices. Cables in such systems must be able to withstand any impressed short-circuit currents for the durations of overcurrent delay. For example, a motor circuit to a 100-hp motor might be required to carry as much as 15,000 amps for a number of seconds. To limit damage to the cable due to heating effect, a much larger size conductor than necessary for the load may be required.

ALUMINUM CONDUCTORS

The use of aluminum conductors for large size feeders can often effect substantial economies in material and installation costs. Allowable current-carrying capacities for aluminum conductors in raceway or cable, in direct burial and in free air are given in Tables 1a and 2a, Chapter 10 of the NE Code. Although comparison between copper and aluminum conductors is usually made on the basis of current rating alone, comparison on the basis of voltage drop is better because practical equivalents are thereby indicated. Of course, aluminum conductors of the same current rating or voltage drop rating as copper conductors will be larger and may require a larger conduit. This must be considered in economic analysis of aluminum conductor application. These considerations are represented in the following tables.

Equivalent aluminum and copper conductors based on voltage drop on three single conductors enclosed in a magnetic conduit 80% power factor, 75°C. Copper temperature and corresponding current-carrying capacities at 30°C. ambient.

Copper Conductors			Aluminum Conductors		
Size	Voltage Drop Phase to Phase per Ampere per 1000 ft	Amperes	Size	Voltage Drop Phase to Phase per Ampere per 1000 ft	Amperes
1/0	.232	150	3/0	.228	168
2/0	.193	175	4/0	.190	193
3/0	.163	200	250MCM	.169	214
4/0	.138	230	350MCM	.134	260
250MCM	.126	255	400MCM	.124	282
350MCM	.104	310	500MCM	.108	319
400MCM	.097	335	600MCM	.098	353
500MCM	.088	380	750MCM	.089	399
600MCM	.082	420	900MCM	.082	437
750MCM	.075	475	1000MCM	.080	458

Conduit sizes for three conductors of equivalent current-carrying capacities

Copper		Aluminum	
3—No. 1/0	2"	3—No. 3/0	2"
3—No. 2/0	2"	3—No. 4/0	2½"
3—No. 3/0	2"	3—No. 250MCM	2½"
3—No. 4/0	2½"	3—No. 350MCM	3"
3—No. 250MCM	2½"	3—No. 400MCM	3"
3—No. 350MCM	3"	3—No. 500MCM	3"

in the case of Wireways (Art. 362), Auxiliary Gutters (Art. 374) and Low-Energy Power, Low-Voltage and Signal Circuits (Art. 725).

Wireways or auxiliary gutters may contain up to 30 conductors at any cross section (excluding signal circuits and control conductors used for starting duty only between a motor and its starter). The total cross-sectional area of the group of conductors must not be greater than 20% of the interior cross-sectional area of the wireway or gutter. And derating factors for more than three conductors do not apply.

It should be noted that neutral conductors which carry only unbalanced current from phase conductors (as in the case of normally balanced 3-wire, single-phase or 4-wire, 3-phase circuits) are not counted when determining the current derating of conductors on the basis of the number in a conduit, as just described. Of course, a neutral conductor used with 2-phase legs of a 4-wire, 3-phase system to make up a 3-wire feeder is not a true neutral in the sense of carrying only current unbalance. Such a neutral carries the same current as the other two conductors under balanced load conditions and must be counted as a conductor when derating more than three conductors in conduit.

Types of Raceways

Feeder conduit may be rigid conduit or electrical metallic tubing for 2-in. or smaller size conduit. Rigid metal conduit of steel or aluminum provides excellent mechanical protection for the conductors, encloses possible faults and is a low-resistance path to ground to assure quick operation of circuit protective devices in the event of fault currents. EMT offers light weight, with ease of handling, cutting and bending.

Other types of conduit and raceways have also found considerable application in modern electrical design:

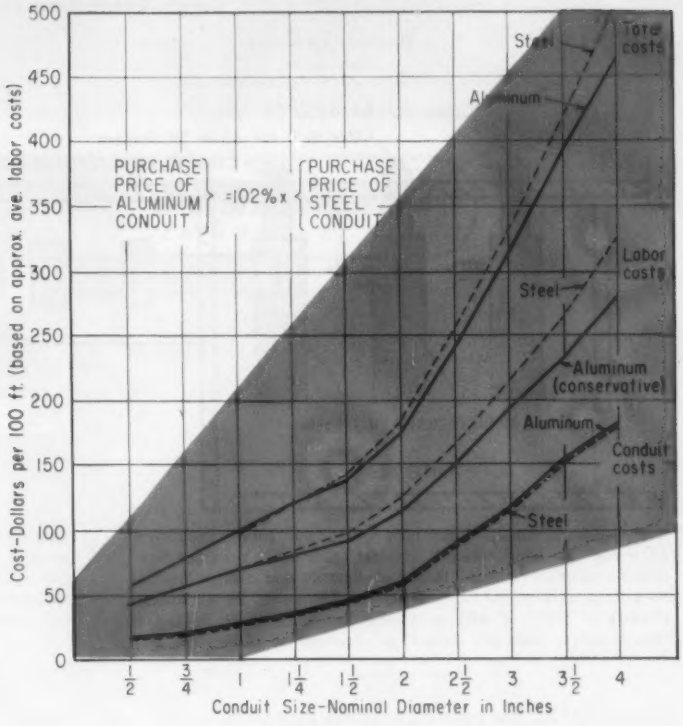
Cable troughs and cable racks are widely used for supporting and routing feeders in many types of industrial buildings. Troughs of metal mesh construction provide a sturdy, flexible system for supporting feeder cables, particularly where routing of the runs is devious or where provision for change or modification in circuiting is important. Cable racks are used for supporting interlocked armor cable feeders in many installations. They have also been used to support secondary feeders of neoprene-jacketed cables.

Asbestos-cement ducts with feeder conductors are also used, offering minimum voltage drop due to greatly reduced conductor reactance, because of the absence of the core effect of magnetic conduit, which increases inductive reactance.

Still another type of conduit used in modern distribution is flexible plastic raceway. In one application, this type of raceway was used for both primary (5-kv) and secondary underground distribution. Primary circuits consisted of single-conductor neoprene-jacketed cables in 4-in. plastic conduits direct-buried in a trench. It should be noted that the cables used in such cases are suitable for direct burial without raceway. The plastic conduit is used to afford maintenance or replacement of the installed cables.

Comparison of Installed Costs of Steel and Aluminum Conduit

Within the past year, substantial reductions in the price of aluminum conduit to the user have brought this product into direct competition with steel conduit on the basis of installed cost. The light weight of rigid aluminum conduit, one-third that of the same size of steel conduit, provides appreciable savings in labor costs. The graph here compares the installed costs of equivalent sizes of steel and aluminum rigid conduit, based on aluminum conduit costing 2% more than steel conduit.



Busways

One of the fastest growing applications in modern electrical design is the busway system. Although use of busway for feeders, plug-in subfeeders and branch circuit systems has been a continuing industrial system development through past years, the use of feeder and plug-in busway in large commercial and institutional buildings is only now coming into widespread acceptance.

Busway has proved a versatile, flexible and economical method of electrical distribution. Offering safety, reliability, ease of layout and efficient operation, busway systems require only basic engineering in their design. And they are capable of carrying large and small blocks of power from main switchboards to load centers to loads.

Although busways have broad application potential, they are limited. The National Electrical Code rules that "busways may be used only for exposed work." Some exception, however, has been made to this rule in cases where concealment is not permanent—such as above certain types of suspended ceilings.

Made up of copper or aluminum busbars mounted on insulators within a steel housing, busways are factory-assembled and supplied in standard 10-ft sections. Busway is available in a number of types and sizes for use in distribution systems:

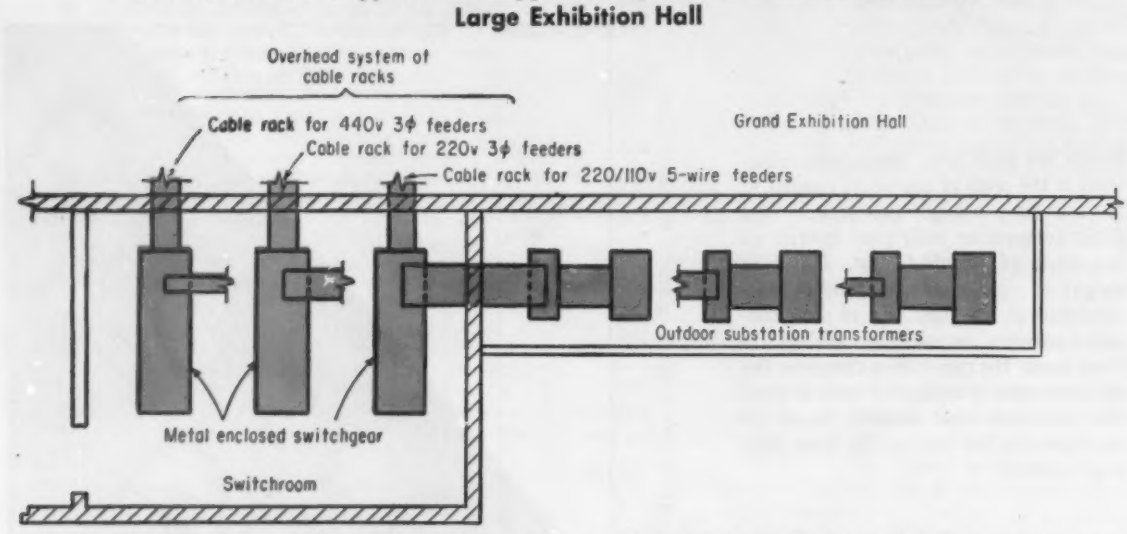
Low-reactance, ventilated feeder busway provides low voltage-drop characteristics due to close spacing and special construction of the busbars which minimizes reactance. This type of busway is used for all types of high-capacity feeders and risers.

Use of Aluminum Conduit

Rigid aluminum conduit is available in sizes from ½-inch to 6-inch diameter. Aluminum EMT is available in sizes from ½-inch to 2-inch diameter. Standard 10-foot lengths are available, including ells and couplings. Typical advantages which can be realized from use of aluminum conduit include:

1. High corrosion resistance to weather and many chemical atmospheres, seldom requiring painting.
2. Reduced voltage drop due to the non-magnetic character of aluminum which minimizes inductive reactance of enclosed conductors, offering important improvement in voltage level and regulation of 60-cycle circuits and providing particular advantage for voltage drop reduction in high-frequency circuits, which have higher reactance in proportion to the frequency increase over 60 cps.
3. Low-impedance equipment ground circuit due to the low resistance and corresponding high current-carrying capacity of aluminum conduit with proper terminal and installation techniques, thereby eliminating the possibility in many cases that circuit protective devices might fail to operate on faults because of high impedance of the ground circuit.
5. Lower labor requirements in installation and reduced support requirements for installed aluminum conduit, both because of its light weight.

Overhead Ladder-Type Racks Support Neoprene-Jacketed Cable Feeders in Large Exhibition Hall


Overhead system of cable racks
Cable rack for 440v 3ϕ feeders
Cable rack for 220v 3ϕ feeders
Cable rack for 220/110v 5-wire feeders
Grand Exhibition Hall
Outdoor substation transformers
Metal enclosed switchgear
Switchroom

A system of conventional neoprene power cables supported on a vast overhead network of steel cable racks provides flexible distribution to many local panelboards and display booths in a large convention hall. Power is distributed by 42 feeder circuits at 220 and 440 volts, supplied from three 1000-kva transformers. Normally conduit or wireway would be used, but cable rack offered much higher flexibility to meet the changing demands of utilization in such a building. Expansion of circuits is readily facilitated and maintenance is easy. Substantial savings in material cost and installation were also realized over conventional raceway.

Because of its low reactance, it has also found application in high frequency distribution system.

Typical ratings on feeder busway range from 600 amps to 4000 amps, for single-phase (2 or 3 poles) or 3-phase (3 or 4 poles), for 120/240-volt single-phase systems, for 120/208-volt or 480/277-volt 3-phase, 4-wire systems or for 3-phase, 3-wire systems, all up to 600 volts. Feeder busways are also available in weatherproof type.

Plug-in distribution busway, with easily accessible plug-in openings for tapping to loads directly or through switch and protective devices, is available in ratings from 225 amps to 1500 amps.

Interlocked Armor Cable

Interlocked armor cable has been in use in electrical work for many years but is only now finding widespread application.

Interlocked armor cable is available for use at 600 volts, 5000 volts and 15000 volts. The high-voltage types of IA cable offer very effective use for primary feeders in load-center distribution systems. The 600-volt class of IA cable is rapidly gaining in popularity for secondary feeder applications in both commercial and industrial electrical systems.

Interlocked armor cable for secondary feeders is a completely flexible and protected cable assembly, available in sizes from No. 6 to 750 MCM, with three or four conductors, IA cable consists of a galvanized steel, interlocked and spiralled armor wrap around the insulated assembly of individually-insulated conductors. The conductors are stranded and may be copper or aluminum. The armor may also be of aluminum or bronze.

There are some general criteria for choosing between IA cable and busway. Where the routing is devious and there are many obstructions, IA cable often can be used to advantage. For straight runs, particularly long runs of high current capacity, busway is usually better. Above 1000 amps capacity, busway for a feeder generally costs less. Below 500 amps, a feeder may more economically be interlocked armor cable. However, where the advantages of busway are required, cost is not as important as achieving the design objectives.

Notes On Underground Distribution

1. **Primary and secondary distribution between buildings can usually be served best by underground installations for a number of reasons:**
   - A. Accident hazards are minimized and isolated.
   - B. Ambient temperature is lowest and cable capacities are highest.
   - C. Cables are not in the way as obstructions to expansion of buildings or as interference to operations.
   - D. Appearance of installations is neater and architectural and landscape design is not marred by unsightly poles.
2. **The cost of underground installations is not always justified under these conditions:**
   - A. Where chemical ingredients in the soil constitute a serious corrosion threat to metal conduits (galvanized steel or aluminum).
   - B. Where extensive changes or expansions of buildings or plants would require removal or alteration of underground feeders.
   - C. Where proper installation of underground circuits is complicated by conditions of the ground such as excessive rock.

presents:

a new and comprehensive line of

electrical connectors

specially designed to meet the

most rigorous specifications

for military and industrial

applications **under severe**

environmental conditions...

ARK-trol®

AVAILABLE IN TWO TYPES:

TYPE

RPE

ENVIRONMENTAL

- Moisture Proof
- Shock Insulated
- Dust-Tight
- Corrosion Resistant
- Grounded and Non-Grounded

TYPE

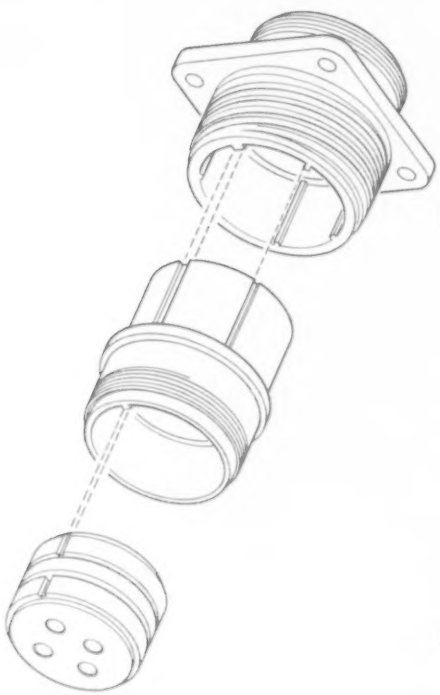
RPC

CIRCUIT BREAKING

- All Features of RPE *Plus* . . .
- Circuit Breaking under Full Rated Load

NEW CROUSE/HINDS Electrical Connectors

. . . insure foolproof polarization, errorless assembly, maximum interchangeability.
. . . meet and exceed rigid military and industrial requirements for resistance to corrosion, chemicals, high and low temperature, pressure, shock, vibration, dust, humidity, moisture, and leakage of air.



POSITIVE POLARIZATION

ARK-trol provides foolproof polarity. Plug can be mated only with the proper receptacle, and in only one way . . . the right way. Key-to-keyway shell matings make improper initial engagements impossible, even in total darkness. Contact arrangements are unsymmetrical, positively preventing improper mating of contacts, or mating of unmatched contact configurations.

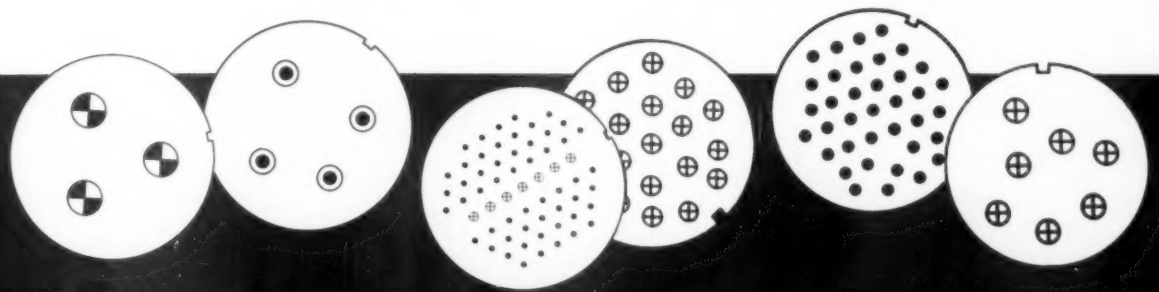
FAST, EASY, ERROR-FREE ASSEMBLY

Insert assembly (insulators and silicone rubber wafer) is notched on outer diameter to prevent mismating or misalignment of parts. Raised key on inner wall of shells will not admit an insert in any but the correct position . . . contacts cannot be inserted into an improperly positioned assembly, due to unsymmetrical arrangement of contact holes. Insulators are numbered on one side only: no chance of reversing. One position for polarity grooves is standard: any of four alternate positions is available on request. High-grade copper alloy 'snap-in' contacts are one piece, standard pin and socket type: soldering is done outside, before installing contacts in assembly. Contacts are silver plated: gold plating available on request. Pressure lugs available to replace solder well type.

MAXIMUM INTERCHANGEABILITY

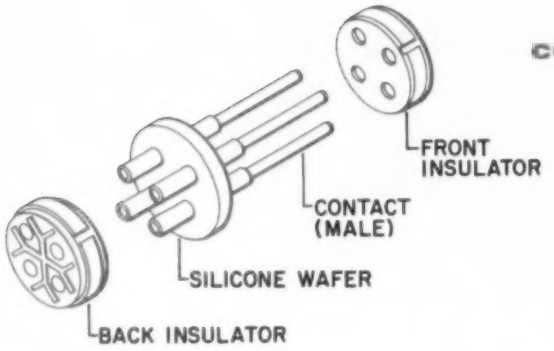
ARK-trol connectors are designed so that the components and assemblies in each diameter are interchangeable and reversible . . . thus doubling the scope of the equipment. Both male and female shells take either pin or socket inserts: both plug and receptacle may be used 'hot' or 'dead'. Pin and socket configurations are available in an extremely wide range. Special configurations and modifications supplied on request.

TYPICAL CONFIGURATION PATTERNS OF ARK-trol CONTACT INSERTS



ARK-trol Provides Positive Seal

against Environmental Factors



COMPRESSED 'STACK' ASSEMBLY

Mechanical compression of insert assembly components is the secret of ARK-trol impenetrability. In this assembly a silicone rubber wafer is 'stacked' between two rigid insulators. As the assembly is compressed within the shell, the outer rim of the silicone wafer is forced against the inner wall of the plug or receptacle shell to form a 'shell seal'. The wafer is also forced tightly against the contacts in the plastic insulators to complete the sealing action. As shell components are tightened, pressure upon insert assembly increases sealing effect . . . positively closing out water, moisture, dust, gas and vapor. Cushioning action of silicone wafer also protects against mechanical damage due to rough handling.

EXTRUDED ALUMINUM CONSTUCTION

All basic shells, gland nuts, etc., are high strength impact extrusions of aluminum, hard coat anodized for resistance to corrosion and abrasion: 1800 volts are required to penetrate this coating. The annealed aluminum shell has a strength approaching that of steel, with less than ⅓ the weight. Extrusion process insures complete accuracy of key-to-keyway fits.

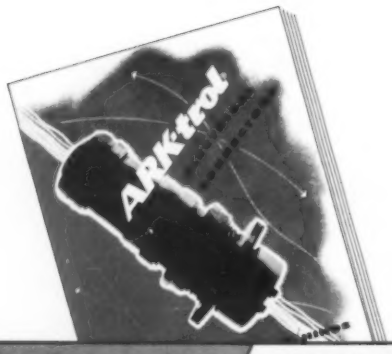
ELECTRICAL RATINGS

Voltages: Military Service Ratings: A, D, E, B, C, and Instrument.
NEC Rating: 600V. A.C.

Contact Sizes: #16 to #4/0 inclusive.

AVAILABLE IN FOUR SHELL SIZES

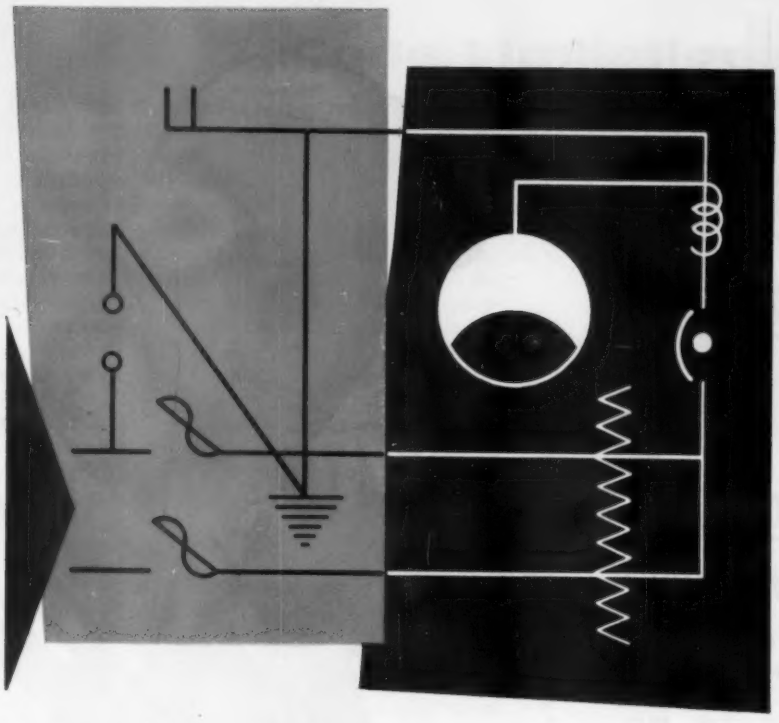
ARK-trol connectors are available in 1 1/16", 1 5/16", 2 1/16" and 2 5/16" diameters. Write for Bulletin 2711, containing complete descriptions . . . specifications . . . configuration patterns . . . service ratings . . . for both Type RPE and RPC ARK-trol Electrical Connectors.



Printed in U.S.A.

CROUSE HINDS
SYRACUSE NEW YORK

OFFICES: Atlanta Baton Rouge Birmingham Boston Buffalo Charlotte Chicago Cincinnati Cleveland Corpus Christi Dallas Denver Detroit Houston Indianapolis Kansas City Los Angeles Milwaukee New Orleans New York Omaha Philadelphia Pittsburgh Portland, Ore. St. Louis St. Paul Salt Lake City San Francisco Seattle Tulsa Washington
RESIDENT REPRESENTATIVES: Albany Baltimore Reading, Pa. Richmond, Va.
CROUSE-HINDS COMPANY OF CANADA, LTD., TORONTO, ONT. CROUSE-HINDS INSTRUMENT COMPANY, INC., SILVER SPRING, MARYLAND



MAKE A FULL-CAPACITY. . . .

SERVICE LAYOUT

THE final major phase of electrical system design is detailed layout of the one or more service entrances required to supply the electrical system in a building.

During preliminary planning for the building, some decision had to be made on the characteristics of the supply or supplies which would best carry the total electrical load. From study and consultation with the local utility and/or from a knowledge of the available utility services and their capacities, the complete system was laid out to tie into the utility lines. But few details other than voltage and phase characteristics were worked out for the service arrangement.

For any building, the service consists of the conductors and equipment used to deliver electric energy from the utility supply lines to the interior distribution system. Service may be made to a building either overhead or underground, from a utility pole line or from an underground transformer vault.

Service layout includes electrical and mechanical factors. Conductors must be provided to connect to the utility source; suitable enclosure and mechanical protection for the incoming conductors must be considered; disconnecting means and overload and short-circuit protection are necessary; and metering and grounding must be accounted for. Step-by-step, design of the service arrangement must cover these factors in their relation to such particular conditions as the type and size of building, requirements of the National Electrical Code and local codes and the regulations and recommendations of the utility supplying the power.

Common Demand Factors for Sizing Service and Main Feeders

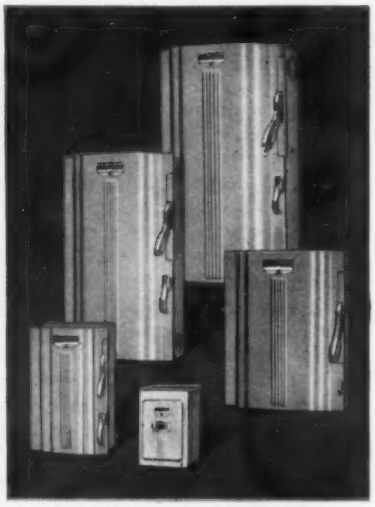
Power Load Devices	Range of Common Demand Factors
Motors for pumps, compressors, elevators, machine tools, blowers, etc.	20 to 60%
Motors for semi-continuous operations in various mills and process plants.	50 to 80%
Motors for continuous operations—as in textile mills.	70 to 100%
Arc furnaces	80 to 100%
Induction furnaces	80 to 100%
Arc welders	30 to 60%
Resistance welders	10 to 40%
Resistance heaters, ovens and furnaces	80 to 100%

"How can safety switches wear out?... They never seem to be doing anything"

The fact that safety switches seem to be doing nothing at all until an emergency arises and somebody rushes to "pull the switch" is very deceptive. Actually, safety switches *work* every minute they are in service, fighting the ravages of unavoidable internal heating... and how well they are built decides how much *safety* your customer has when he really needs it.

Normal full-load current passing through the fuses in a safety switch generates considerable heat, temperatures as high as 700° F are not uncommon. This is not a criticism of fuses because they must operate close to their *melting* point at full load if they are to function properly when an overload occurs. But the continual heating of the switch mechanism in the confined enclosure creates a serious *heat* problem. Metal parts warp and corrode. Contacts loosen, then either weld or *burn up.*

Cutler-Hammer engineers tackled the problem of internal heating and licked it. Cutler-Hammer *Heat-Proof* Safety Switches use only selected heat resistive materials and a design that conducts away the trapped heat. Why settle for less when Cutler-Hammer *Heat-Proof* Safety Switches cost no more. Write today for your handy selection guide, C-H Merchandiser, Pub. EA100- K241. Cutler-Hammer Inc., Milwaukee 1, Wis.



There's a Cutler-Hammer *Heat-Proof* Safety Switch built to serve every job requirement. Your careful selection guarantees your customer's safety.

CUTLER-HAMMER CONTROL

CUTLER·HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* Airborne Instruments Laboratory. • *Subsidiary:* Cutler-Hammer International, C. A.

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

Code Limitations

Article 230 of the code covers requirements for services. Typical provisions referring to design limitation are as follows:

1. Although the code states that "a building shall be supplied through only one set of service conductors," there are exceptions made. If more than one service drop is made to a building, more than one set of service conductors may be used to supply the building. In the case of apartment houses, shopping centers and other multiple-occupancy buildings, which do not have individual occupancy above the second floor, two or more sets of service entrance conductors may be tapped from a single set of service drop conductors or two or more sub-sets of service entrance conductors may be tapped from a single set of main service entrance conductors. Cases of separate light and power services to a single building and separate services to water heaters for purposes of different rate schedules are exceptions to the general rule of single service.

2. Only one service drop may be used to supply a building from a single transformer or from a single secondary utility distribution system. Exceptions to this rule are made under several conditions. If a separate service is necessary for fire pumps or for emergency lighting, or if the size and layout of the building and its load cannot be handled by a single service, or if the building has multiple-occupancy without space for service equipment accessible to all occupants, or if an additional service of different voltage or other characteristics is needed for special classes of use, more than one service drop may be used.

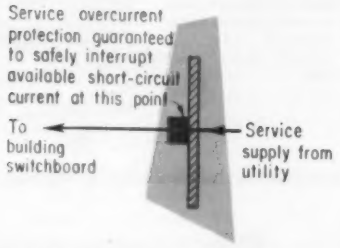
Particular installation and construction requirements for overhead and underground services are covered in detail in the code. This includes wiring methods, construction of equipment and required mechanical protection for conductors.

Sizing Service Conductors

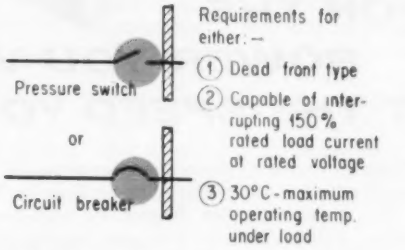
Sizing of service entrance conductors involves the same type of step-by-step procedure as used to size feeders. In general, the service entrance conductors must have a minimum current-carrying capacity sufficient to handle the total lighting and power load served.

Where the code gives demand factors to use or allows the use of acceptable demand factors based on sound engineering determination of less than 100% demand requirement, the lighting and power loads may be modified in this calculation. Section 2203 of the code gives demand factors for general

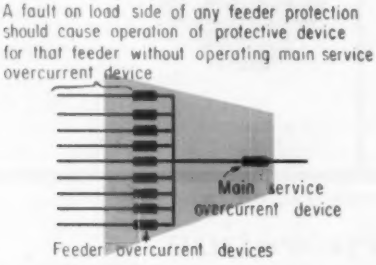
Modern Design Elements of Secondary Voltage Services


Service overcurrent protection guaranteed to safely interrupt available short-circuit current at this point
To building switchboard
Service supply from utility

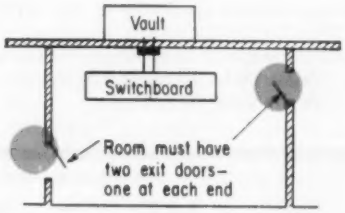
MAXIMUM PROTECTION for service installation is assured by mounting service protective devices of adequate interrupting capacity for the short-circuit duty as close as possible to the service terminals at the building wall.


Requirements for either:—
Pressure switch
(1) Dead front type
(2) Capable of interrupting 150% rated load current at rated voltage
or
Circuit breaker
(3) 30°C - maximum operating temp. under load

EFFECTIVE DISCONNECT means should be a pressure-contact switch or a circuit breaker, of suitable design for service application with ability to withstand possible short-circuit stresses at the point of its application.


A fault on load side of any feeder protection should cause operation of protective device for that feeder without operating main service overcurrent device
Main service overcurrent device
Feeder overcurrent devices

SELECTIVE PROTECTION for main switchboard and service should follow the characteristics described in the section on distribution, to minimize outage in event of faults.



SWITCHBOARD ACCESSIBILITY to provide disconnecting of service in the event oif fire is increased by the use of two separate doors, one at each of opposite ends of the room.

WAGNER Integral-Type Gearmotors

FOR THE POWER YOU WANT AT THE SPEED YOU NEED

Wherever you need "slower than motor speeds" you can get positive speed reduction with plenty of power by using Wagner Gearmotors.

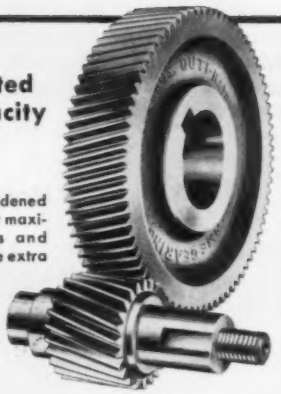
This extension to the Wagner line provides compact motorized drives, with both motor and gear housing of corrosion-resistant cast iron. Available with the latest NEMA Frame open protected or totally enclosed fan-cooled motors, they combine Wagner motor dependability with rugged, simplified gear units to give you speed reduction equipment designed for greater capacity and longer life in ordinary up to rough service.

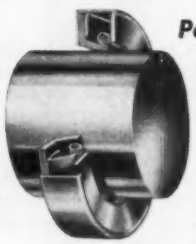
Wagner Gearmotors offer a wide variety of sizes in single, double, triple or quadruple reductions, horizontal or vertical foot or flange mountings—speeds from 7½ to 780 RPM. Write for Bulletin MU-227.

Whether you specify or apply power transmission equipment, your nearby Wagner Sales Engineer will be glad to help you select the right drive for your applications.

Heat treated high capacity helical gears

Gears are hardened after cutting, for maximum hardness and accuracy, to give extra capacity and longer wear life.





Positive Oil Seals

Improved lip type seals are used on horizontal shafts. On vertical output shafts, double mechanical seal with slinger and drain-off gives positive protection against leakage.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

WM59-12

Wagner Electric Corporation

6413 Plymouth Ave., St. Louis 14, Missouri.

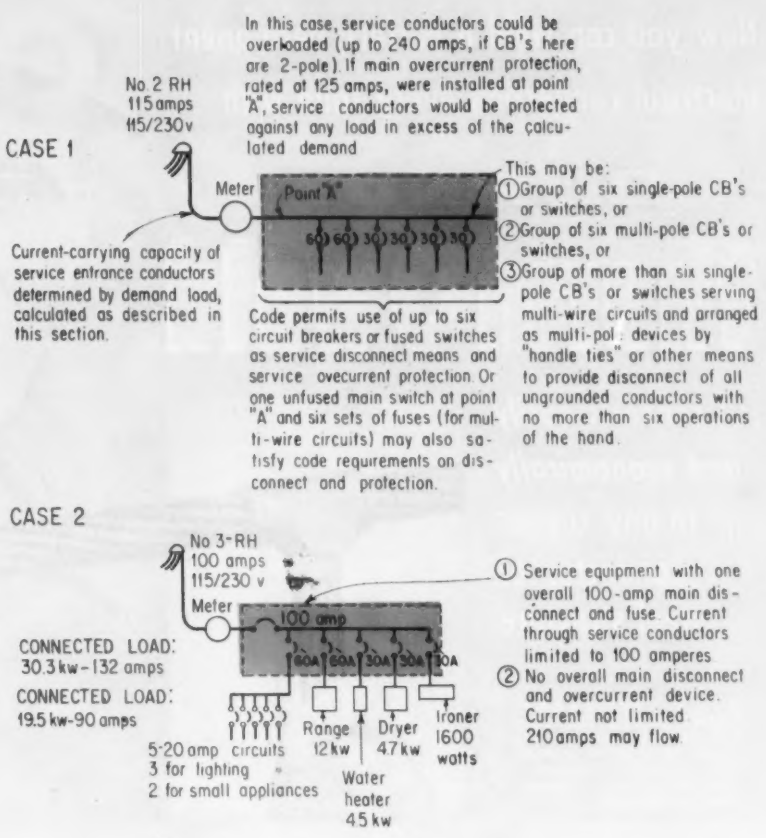
SERVING 2 GREAT GROWTH INDUSTRIES . . . *ELECTRICAL . . . AUTOMOTIVE*

Service Overcurrent Protection

Each ungrounded service entrance conductor must be protected by an overcurrent device in series with the conductor. The overcurrent device must have a rating or setting not higher than the allowable current-carrying capacity of the conductor, except as follows:

1. If the service supplies motor loads, the overcurrent device may be rated or set in accordance with the required protection for a feeder supplying several motors or for a feeder supplying a power and lighting load. If only a single motor is supplied, the overcurrent protection should include a value of rating or setting equal to that used to protect the motor branch circuit.

2. Not more than six circuit breakers or six sets of fuses may serve as overcurrent protection for the service entrance conductors. The accompanying diagrams indicate the application and protective limitations of this six subdivision method.


In this case, service conductors could be overloaded (up to 240 amps, if CB's here are 2-pole). If main overcurrent protection, rated at 125 amps, were installed at point "A", service conductors would be protected against any load in excess of the calculated demand
No. 2 RH
115 amps
115/230 v
CASE 1
Meter
Point "A"
60 60 30 30 30 30
This may be:
① Group of six single-pole CB's or switches, or
② Group of six multi-pole CB's or switches, or
③ Group of more than six single-pole CB's or switches serving multi-wire circuits and arranged as multi-pole devices by "handle ties" or other means to provide disconnect of all ungrounded conductors with no more than six operations of the hand.
Current-carrying capacity of service entrance conductors determined by demand load, calculated as described in this section.
Code permits use of up to six circuit breakers or fused switches as service disconnect means and service overcurrent protection. Or one unfused main switch at point "A" and six sets of fuses (for multi-wire circuits) may also satisfy code requirements on disconnect and protection.
CASE 2
No. 3-RH
100 amps
115/230 v
Meter
100 amp
60A 60A 30A 30A 30A
① Service equipment with one overall 100-amp main disconnect and fuse. Current through service conductors limited to 100 amperes
② No overall main disconnect and overcurrent device. Current not limited. 210 amps may flow.
CONNECTED LOAD:
30.3 kw-132 amps
CONNECTED LOAD:
19.5 kw-90 amps
5-20 amp circuits
3 for lighting
2 for small appliances
Range
12 kw
Dryer
4.7 kw
Ironer
1600
watts
Water
heater
4.5 kw

lighting and receptacle loads (the table listing these factors is given in the DISTRIBUTION section of this manual). Section 4316 of the code allows use of demand factors for motor loads, provided the factors are approved by the code-enforcing authority. Typical power-load demand factors are given in an accompanying box in this section.

LIGHTING: The first step in sizing the service entrance conductors is determination of the total lighting load to be served. This figure is the sum of all of the individual lighting branch circuit loads, which were determined as part of the feeder-sizing procedure.

The total lighting load in watts must not be smaller than the product of the total square feet of floor area in the building and the value of watts-per-square-foot given for the particular type of occupancy in the code table in Section 2203 (or higher watts-per-square-foot values from accepted tables of unit loads). This, however, would be the barest minimum load figure for lighting.

If the total sum of actual connected loads on lighting branch circuits can be determined, a more accurate sizing of the service conductors will result. But this figure must at least be equal to the minimum watts-per-square-foot times the total floor area.

DEMAND FACTORS: The second step in the procedure is adjustment of the total lighting load by use of demand factors. From the table in Section 2203, it can be seen that in the great majority of occupancies a demand factor of 100% is used for the total wattage. This follows from the reasonable probability that in such occupancies the entire lighting load might be in operation simultaneously.

In the case of dwelling occupancies—single residences and apartment houses, hospitals, hotels, office buildings and warehouses, demand factors may be applied to various amounts of connected lighting load on the branch circuits. In those types of buildings, simultaneous operation of even a large part of the lighting load is unlikely. The service entrance conductors, therefore, do not have to be able to provide power for the entire load at once.

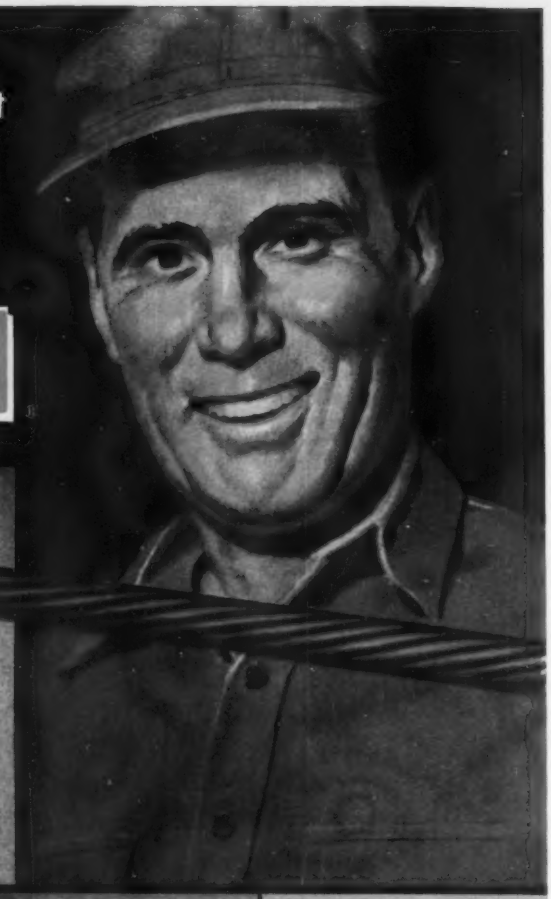
The general use of a 100% demand factor for lighting is, however, highly recommended. Even where demand factors may be applied, the designer should relate this allowance to probable conditions of utilization and raise the minimum demand factors when he thinks it necessary. In any event, the final total lighting load should be arrived at in these first two steps.

APPLIANCES: The next load, to be added to the total lighting load, is the small appliance load to be served by convenience receptacles. In apartment houses with provisions for cooking by tenants, at least 2000 watts for small kitchen appliances must be allowed for each apartment. In hotels having suites with serving pantries, at least 2000 watts must be allowed for each suite.

Now you can weld a perfect, permanent electrical connection every time with

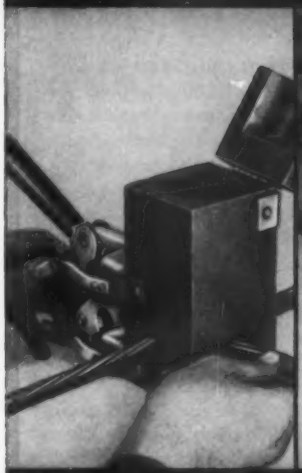
BURNDY

thermOweld



. . . connects easily and economically to any copper conductor or steel structure

Get a permanent THERMOWELD connection quickly . . . never corrodes or loosens, costs little to install. Current-carrying capacity higher than conductors.

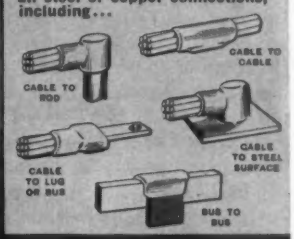


Weld anywhere, to cable or flat, with this compact, lightweight THERMOMOLD. Completely self-contained . . . needs no external source of power, no special skill.

Pour welding powder into mold, tap to release starting charge. Unique composition of starting charge prevents mixing with welding powder, assures positive firing. Slag easily removed.

Close cover and ignite charge with flint gun. Fast-burning powder fires every time. THERMOWELD reaction forms liquid copper which fuses conductors into a solid copper mass.

You can THERMOWELD almost all steel or copper connections, including . . .



THERMOWELD fires every time. Cartridges sealed in polyethylene envelopes with moisture absorbing silica gel. Starting, welding charges can't mix . . . full starting charge assures ignition.

All components are available from your local Burndy distributor. Ask him or your Burndy representative for a demonstration.

BURNDY

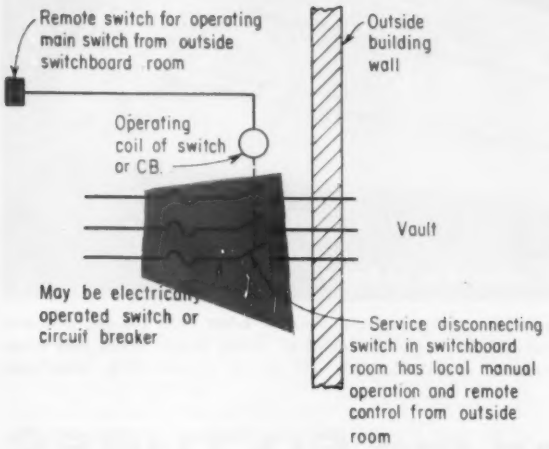
59-4

Norwalk, Connect. In Europe: Antwerp, Belgium Toronto, Canada

Notes on Service Disconnecting Means

1. Service entrance conductors must be equipped with a readily accessible means of disconnecting the conductors from their source of supply.

2. The disconnecting means must be manually operable and may be a switch or circuit breaker of the air-break or oil-immersed type, equipped with a handle or other identified means of mechanical operation by hand. Electrical operation of the disconnect means may also be used in addition to the mechanical handle. Such operation can be adapted to remote pushbutton control to provide for opening the service when fire or other conditions make the mechanical handle of the disconnect means inaccessible. Remote electrical operation is required by some local codes. A typical arrangement is as follows:


Remote switch for operating main switch from outside switchboard room
Outside building wall
Operating coil of switch or CB
Vault
May be electrically operated switch or circuit breaker
Service disconnecting switch in switchboard room has local manual operation and remote control from outside room

3. The disconnect may consist of not more than six switches or six circuit breakers, in a common enclosure or individual enclosures, located either inside or outside the building wall as close as possible to the point at which the conductors enter the building. Single-pole switches or circuit breakers equipped with handle-ties may be used in groups as single disconnects for multi-wire circuits. Multi-pole switches and circuit breakers may also be used as single disconnects. The requirements of the code are satisfied if all of the service entrance conductors can be disconnected with no more than six operations of the hand—regardless of whether each hand motion operates a single-pole unit, a multi-pole unit or a group of single-pole units controlled by a single hand motion.

4. Each occupant in a multiple-occupancy building must have access to his disconnecting means.

5. For a group of buildings under single management, disconnect means must be provided for each building.

6. If an emergency power supply is provided to feed the conductors controlled by the service disconnecting means, the disconnector must be of such design that the regular supply is disconnected before the emergency supply is connected—unless special provisions are made for parallel operation and suitable control.

7. Service fuses, meters, high-impedance shunt circuits (such as meter potential coils), supply conductors for time switches, surge protective capacitors, instrument transformers, lightning arresters and circuits for emergency systems, fire pump equipment and fire alarms may be connected on the supply side of the disconnecting means.

In non-dwelling occupancies, in which the load represented by general-purpose convenience receptacles is not included with the lighting load, as it is in the case of dwelling occupancies, the sum of the design loads used for general-purpose (1½-amp) receptacle branch circuits must be determined and added to the total lighting load. Although the code permits the addition of these loads to connected lighting loads and application of demand factors to the total, it is recommended that these appliance loads be taken at 100% and added to lighting loads only after any demand factors are applied.

Special Loads

Continuing the summation of loads to arrive at a total load to be supplied by the service, there are special loads which must be added for different types of buildings.

SHOW WINDOW LIGHTING: If the occupancy under consideration is a store, a minimum load of 200 watts must be allowed for each linear foot of show window, measured horizontally along the base.

ELECTRIC RANGES: If the building is an apartment house, a total load must be added for electric cooking ranges and appliances used in the building. The total range load in watts for a number of ranges can be determined from Table 29 in Chapter 10 of the code. This table covers ranges and cooking appliances rated over 1,750 watts. Where ranges of less than 8.75 kw are used, the values of load used in calculations should not be less than those given in Column A of the table, to allow future installation of larger ranges.

MAJOR APPLIANCES: If fixed appliances (excepting electric cooking appliances and space heating equipment) are part of the load in a building, the sum of their ratings must also be added as part of the total load. The ratings of these appliances should be readily available from the branch circuit design calculations, in which each fixed appliance was provided with an individual branch circuit.

ELECTRIC HEATING: For electric space heating in a building, the service entrance conductors must also include an amount of capacity equal to the sum of all of the individual connected loads on the system. This is equal to the sum of the unit heater ratings in watts.

If some of the heating equipment is operating on duty cycle or intermittently or if for any reason all of the units will not be operating simultaneously, a demand factor of less than 100% may be applied to the total heating load. But permission of the code enforcing authority must be obtained.

Adding Motor Loads

The next load which must be accounted for in sizing the service conductors is the motor load. This

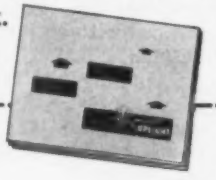
Today's Best Lighting Value for Every Industrial Application

DAY-BRITE'S NEW CFI®
CFI-25 for Rapid Start, High-Output R.S., or Slimline Lamps
CFI-30 for New Power-Groove and other Extra High-Output Lamps
Pat. No. D-177,522
CFI means Comfort For Industry

25% uplight washes out harsh ceiling contrasts. "Up-draft" action provides more efficient self-cleaning. Center "V" and closed ends for added shielding and strength. Reflection surfaces are lifetime porcelain enamel for easy cleaning. 8-foot rigid channel, one-piece reflector for simplified installation. Spring-loaded sockets hold lamps securely, speed relamping. *All this at up to 17.7% lower cost!*

Get the FACTS...and the FIXTURES

Now industrial fixture buyers can get more light with greater eye comfort at lower installed cost, lower operating cost, and with lower annual owning costs. Today's lower-priced Day-Brite CFI-30, used with new Power-Groove lamps, actually reduces the cost of lighting industrial areas *as much as 54%*. For detailed information, call your Day-Brite representative listed in the Yellow Pages of your phone book. Or use the coupon below.



Day-Brite Lighting, Inc.
6248 N. Broadway
St. Louis 15, Missouri

GENTLEMEN: Please send me information about Day-Brite's new CFI fixture and "Operation Uplight."

Name_____

Title_____

Firm_____

Address_____

City_____ Zone____ State____

Look for this emblem displayed by Distributors offering Day-Brite Comfort for Industry fixtures—available now for immediate delivery!

A-120 © 1959 by Day-Brite Lighting, Inc.

eye-li
DECIDEDLY BETTER
DAY-BRITE
LIGHTING FIXTURES

DAY-BRITE LIGHTING, INC.
St. Louis, Mo. • Santa Clara, Calif.

NATION'S LARGEST MANUFACTURER OF COMMERCIAL AND INDUSTRIAL LIGHTING EQUIPMENT

includes all motors supplied by the service (excepting appliance motors already accounted for).

The minimum allowance to make for the total motor load is equal to 125% of the rating of the largest motor supplied plus the sum of the ratings of the other motors. This is the standard feeder calculation for conductors supplying several motors.

According to the code, less than 100% demand factor may be applied to the total motor load under certain conditions and with the approval of the authority enforcing the code. Typical conditions permitting use of less than 100% demand for motor load include those cases where reduced heating of conductors results from motors operating on duty-cycle or intermittently or from non-simultaneous operation of all motors. In all such cases, however, the nature and size of the load must be carefully studied. Only sound, conservative engineering analysis is an acceptable basis for the use of a demand factor.

OTHER POWER LOADS. Finally, other power loads not previously considered should be added to the total load to be supplied by the service entrance conductors. Here again, 100% demand should be used unless it can be fairly well established that not all of this power load will be operating at the same time.

Total Load

From the foregoing steps, a total power and lighting load can be developed to use in sizing service entrance conductors. Of course, where separate power and lighting services are used, the above indicated procedure should be divided into two separate procedures. In any case, the load established will be an initial load and in many cases will be the minimum load to use in sizing the conductors.

Depending upon the type of building, the size and type of service selected, the size and makeup of the total load and a study of all of these conditions, it will often be advisable and frequently necessary that an allowance for 50% growth in load be included in the service conductors. No strict rule can be applied to this consideration. It is a matter for the individual engineer to use his knowledge and experience in allowing such extra capacity in the service as he thinks best for the particular design. Allowance for load growth should be made for service conductors under the same conditions for which growth capacity would be provided in feeders.

Emergency Systems for Electric Energy Supply

In occupancies where interruption of electrical power supply to the building would result in panic, hazard to life or property or major production loss, provision should be made for emergency supply of power in the event of failure of the regular supply. Such provision may be made by designing an emergency system of distribution and circuits supplied by—

1. **Storage batteries,**
2. **Emergency generator set,**
3. **Separate emergency service or**
4. **Subservice tapped ahead of disconnect means for the normal service conductors.**

Detailed requirements and recommendations for emergency electrical systems are given in Article 700 of the NE Code.

Sum of Feeder Loads

Although the general concept of sizing service presented above is suitable for all types of load concentrations, it is also possible to size service entrance conductors by summing feeder loads which are supplied directly from the service.

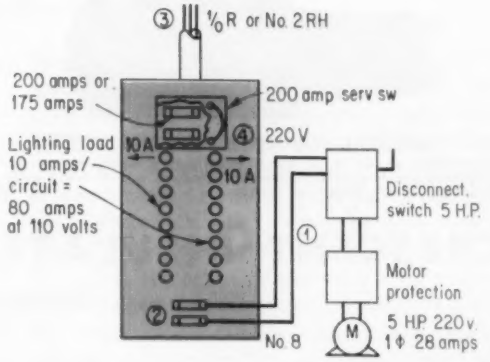
In the case of separate power services, it can frequently be found by examination of the conditions that 100% demand of the sum of the feeder loads provides substantial service capacity. And in all cases where feeders have been sized for 100% demand of their branch circuit loads, the same 100% demand would have to be applied to the loads in computing service capacity. The result is that the

Service Calculations for Motor and Lighting Load

(Basic NE Code Method)

1. Size of motor branch circuit conductors: 125% x 28 amps equals 35 amps. This requires No. 8's (Sec. 4312)
2. Size of motor branch circuit fuses: 300% x 28 amps equals 84 amps. This requires maximum fuse size of 90 amps or 100 amps. Smaller fuses, such as time-delay type, may be used. (Secs. 4342, 4346 and 4349)
3. Size of service entrance conductors: 125% x 28 amps plus 80 amps (lighting load) equals 115 amps (Sec. 4315).
4. Size of main fuses: 90 amps (from 2 above) plus 80 amps equals 170 amps. This requires maximum fuse size of 200 amps. Again, smaller fuses may and should be used where possible to improve the overload protection on the circuit conductors. (Sec. 4363)

NOTE: Values given here may vary with characteristics of motor. See Tables 26 and 27, Chapter 10, NE Code.



CRESCENT

OVER 75 YEARS EXPERIENCE

Insulated Wires and Cables

Pictured and described here are just a few of the many wires and cables that are made by CRESCENT.

ABC ARMORED CABLE

Has prefabricated breaking lines which make installing easier, quicker and safer. A flattened bonding wire in contact with the underside of each convolution of the armor assures a permanent low resistance of armor.

SYNTHOL BUILDING WIRE — TYPE TW

For both wet and dry locations. Insulated with a special, tough thermoplastic compound. High dielectric and mechanical strength. Smallest outside diameter for same conductor size permits more or larger conductors in same space.

ENDURITE BUILDING WIRE — TYPE RH-RW

A dual purpose wire for either dry or wet locations. Type RH has a greater carrying capacity because of higher permissible operating temperature, which allows use of smaller size cable at less cost.

IMPERVEX TRENCHWIRE — TYPE USE-RR

Single conductors for direct earth burial. Has a heavy Neoprene jacket over the rubber insulation. Provides low cost, permanent underground cable installation.

STEEL TAPED PARKWAY CABLE

Designed for direct earth installation without additional protection. All standard types regularly supplied and special type cables made to customers' specifications.

IMPERIAL PORTABLE POWER CABLE

Illustration shows Type SH-D 5000 Volt Trailing Cable for supplying power to electric shovels, dredges, etc. Covered with extremely tough Neoprene jacket.

TYPE UF AND TYPE NMC

Used for direct earth burial as an underground feeder, also used for branch circuit wiring in damp or corrosive locations.

BUILDING WIRE — TYPE RHW

Braid or Neoprene covered

Highest quality insulation, for use in both WET and DRY locations at 75° C.

CRESFLEX

Most suitable, lowest cost for rural, residential and farm buildings. Clean, gray paint finish.

SERVICE CABLES — TYPE SE

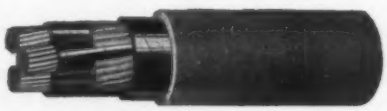
Both Style A (armored) and Style U (unarmored) are approved by Underwriters' Laboratories as service entrance cable and may be run down the side of a building without additional protection. It is tamper-proof, flexible and lightweight, moisture-resistant and flame-retarding.

NEOPRENE CRESCORD

Heavy duty, oil-proof portable cord, Underwriters' Laboratories Type SO.

INTERLOCKED ARMOR POWER CABLE

Provides a flexible, metal-enclosed method of wiring for power.



VARNISHED CAMBRIC LEAD ENCASED CABLE

Varnished cambric insulation has high dielectric strength and long life. Not affected by oils and greases. This cable is supplied with lead sheath for wet locations or weatherproof braid for dry locations.

CRESCENT INSULATED WIRE & CABLE CO.

TRENTON 5, N. J.

Primary and Secondary Supplies Require Coordination of Service Components

In selecting service conductors, service disconnecting means and service overcurrent protection, care should be taken to coordinate the ratings and characteristics of such equipment for maximum safety. Typical considerations include the following:

1. Continuous current rating of disconnect must be sufficient for full-load current, and its momentary current rating must be such that the device can withstand possible short-circuit currents for the length of time it takes for the circuit to be cleared.

2. Interrupting capacity of disconnect must be sufficient for any possible conditions of operation. Requirements for interruption of loads and overloads must be related to time-current characteristics of service protection devices. On primary circuits, disconnect should usually be able to break full-load current up to its own rating. On secondary circuits, switch may need interrupting ability anywhere from its own current rating up to more than 10 times its current rating, depending upon the ampere-seconds calibration of the associated protection.

3. Protective device must be able to safely open the current which could be delivered into a short circuit on its own load terminals, and its time-current characteristic for overloads must be matched to the disconnect and to devices on its load side which have to withstand the let-through energy of short circuits.

4. Service busway and other service conductor arrangements must be sized and designed to assure safe application with the service disconnect and protection.

---

service capacity works out to be equal to the sum of the feeders. And if feeders were sized for growth in the load, the summation of their carrying capacities would contain appreciable spare capacity.

When a total load—initial and future—has been established for the service entrance conductors, the required current-carrying capacity is easily determined by dividing the total load in kva (or kw with proper correction for power factor of the load) by the voltage of the service. This operation is the same as for feeders and involves the same formulas given in the previous section.

From the required current rating of conductors, the required size of conductors is determined. Sizing of the service neutral is also the same as for feeders. Use of multiple conductors per phase instead of a single large conductor, discussed in the previous section, offers clear advantage for makeup of service entrance conductors.

High-Voltage Service

Special design considerations are involved in laying out high-voltage services. The utility will assist the designer in many of the details of such work. General requirements are as follows:

— Transformers used indoors in primary supplies rated over 15,000 volts must be installed in transformer vaults as described in Sections 4541 to 4548.

— A transformer rated up to 15,000 volts may be installed in a building without vault or fire-resistant room provided that (1) it is filled with a liquid that will not burn (askarels), (2) it has mechanical protection, (3) it is properly ventilated, and (4) it is inaccessible to unauthorized persons.

— Primary switches, circuit breakers and associated control equipment used in systems rated up to 15,000 volts need not be installed in vaults or fire-resistant rooms if the equipment is constructed and approved for use without a vault. Manufacturers' literature covers construction, operation and application of primary switchgear and should be followed closely.

In selection of switchgear, the required interrupting capacities will be based on the short-circuit capacity of the supply and the impedance of the transformers. Discussion with utility engineers will assure proper selection of primary switchgear and secondary feeder protection to meet the available short-circuit duty of the supply, eliminating hazards due to insufficient interrupting capacity.

Seven Rules for Grounding

1. Ground at power source or power sources only. See data on Grounds in the section on Distribution. Power source may be point at which utility lines come into building. If transformations are made to several voltage levels, ground each level at the transformer secondary. Do not ground at points of power utilization.
2. On low-voltage circuits, impedance of the equipment ground must not limit fault current below rating of protective device.
3. All parts of the complete system must be grounded. Ground at each major bus section if it is possible to separate each bus section.
4. Except on low-voltage generators equipped with special coil bracing, generator neutrals must not be grounded solidly. A grounding reactor should be used on Y-connected low-voltage generators, and a grounding resistor on high-voltage units.
5. Neutral grounded systems require overcurrent devices for all phases. Only two running overload relays are required for running protection of motors.
6. If it proves economical, a grounding transformer may be used where a system neutral is not available.
7. The service ground conductor should have a carrying capacity not less than 25% of the main capacity.

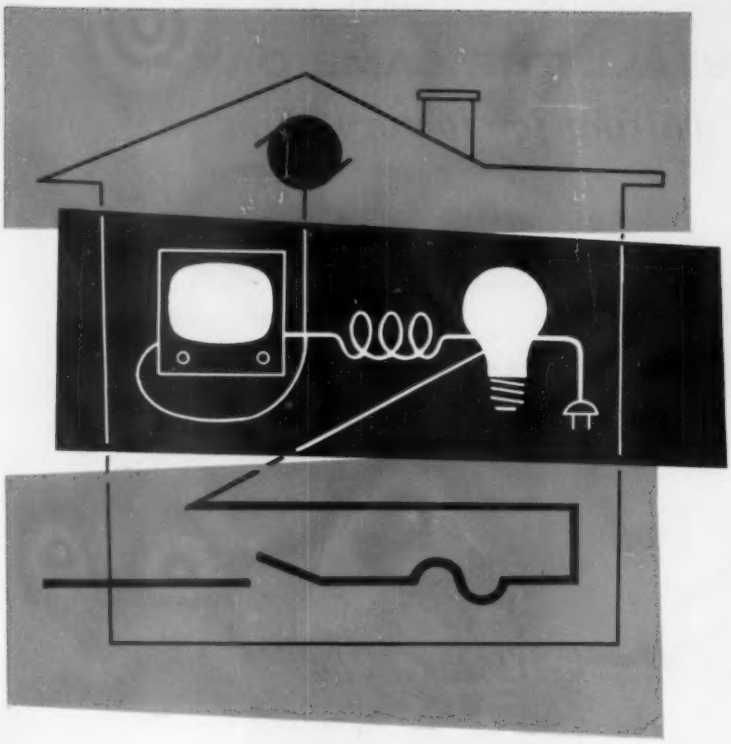
100% CBM CERTIFIED

Sola ballasts guard your reputation with 100-percent CBM certification. There is no "second line" at Sola.

Every Sola fluorescent ballast for general-lighting service, for which a CBM specification exists, is a CBM-certified ballast—and then some! They top CBM specs by comfortable margins. You can install, furnish, or specify Sola knowing that reserve tolerances—conservatively engineered into every unit—assure full-rated ballast life and light output.

Lamps and fixtures operating with cool, efficient, trouble-free Sola ballasts deliver all the performance demanded by their designers. The man who's buying the light expects nothing less, and it's up to the contractor, the fixture manufacturer, and the engineer to see that he gets it. Sola ballasts guard your reputation. Why not call your district sales engineer and get the facts. ***Sola Electric Co.*** (A Division of Basic Products Corporation) ***4633 W. 16th Street, Chicago 50, Illinois.***

SOLA BALLASTS



MATCH MODERN LOADS IN . . .

RESIDENTIAL WIRING

ELECTRICAL system design for a residence follows the same general procedure as used for commercial or industrial design:

1. The conditions of load must be analyzed, both present loads (known initial loads) and anticipated future loads.

2. From this study, the number and sizes of branch circuits are determined.

3. Then by combining all of the branch circuit loads into a single load, the requirements of the service entrance to handle the total load can be determined.

The methods and procedure for modern residential electrical design are revealed in the following breakdown of these steps. The objective through the complete procedure is to arrive at a load-matched wiring system for the home—a system matched by today's standards to the load represented by the many appliances and utilization devices which make for better living electrically.

Lighting Outlets

Based on a study of initial load requirements, the first step in residential design involves layout of outlets for fixed lighting fixtures. This includes kitchen lighting, hall lighting, foyer lighting, bathroom lighting, basement lighting, front and rear door lighting, garage lighting and other fixed lighting units.

Lighting layout may require selection of particular lighting units of various sizes to meet requirements of the builder or home buyer. In indicating these outlets on a set of floor plans for the house, the known or estimated watts to be served by each outlet should be noted.

Plug Receptacles

The next step is provision of receptacle outlets to afford convenient use of electrical appliances in the various areas of the home. Receptacles are available in many sizes and types. There are standard duplex and triplex convenience receptacles, multi-outlet strips and moldings with flexible arrangements of convenience receptacle outlets, weatherproof outlets with protective caps for use on outdoor patios and in other outdoor areas, hanger outlets for clocks and fans, safety receptacles for children's rooms, polarized receptacles to take a grounding connection for appliances, locking-type receptacles to hold plugs in the connected position and special purpose

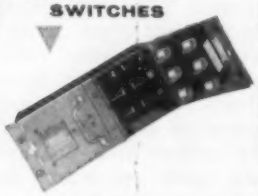
FRANK ADAM DISTRIBUTION PANELBOARDS

▲ SIX ENCLOSURE SIZES
Mains, 250, 400 or 600 amperes — for single phase 3-wire, 3-phase 3-wire, 3-phase 4-wire.

PULL-OUT SWITCHES

30, 60 or 100 amps.— 250-v.
30 or 60 amps. 600-v.

HINGED TYPE SWITCHES



30,60, 100 or 200 amps.—250-v.

Off-the-shelf delivery from your local wholesaler! Just get the type and number of switches you need, plus the right-size enclosure, and complete the installation on the same day.

Plug-in branches, used with filler spacers in enclosures larger than necessary for immediate requirements, make it easy to change switch capacities or add extra branches in the future. Choose from two types of plug-in switches—pull-out or hinged type.

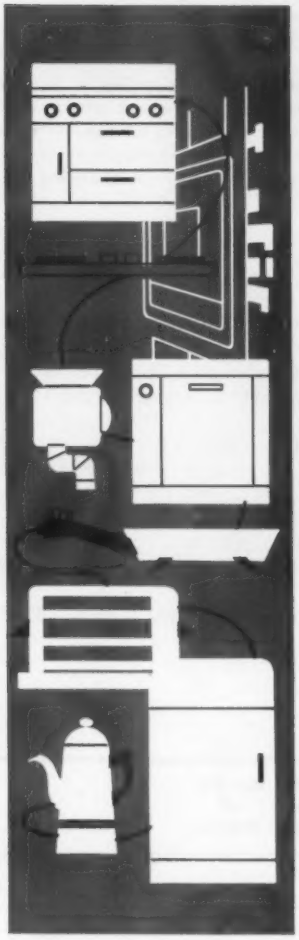
Save time, trouble and money with Ⓕ Feeder Panelboards—tops in quality, safety, dependability. Your Wholesaler has them in stock.

See our catalog in SWEETS

FRANK ADAM ELECTRIC COMPANY
P. O. BOX 357, MAIN P. O. · ST. LOUIS 66, MO.

busduct · panelboards · switchboards · service equipment · safety switches · load centers · Quikheter

Use These Circuits in Kitchen and Dining Areas



	Typical Load in Watts	Volts	Wires	Circuit Breaker or Fuse	Number of Outlets	Notes
RANGE	12000	120/240	3- #6	50-60A	1	Use of more than one outlet is permitted, but not recommended.
OVEN (Built in)	4500	120/240	3- #10	30A	1	Appliance may be direct connected.
RANGE TOP	6000	120/240	3- #10	30A	1	Appliance may be direct connected.
RANGE TOP	3300	120/240	3- #12	20A	1 or more	
DISHWASHER	1200	120	2 #12	20A	1	These appliances may be direct connected on a single circuit. Grounded receptacles required, otherwise.
WASTE DISPOSER	300	120	2 #12	20A	1	
BROILER	1500	120	2 #12			Heavy duty appliances regularly used at one location should have a separate circuit. Only one such unit should be attached to a single circuit at a time.
FRYER	1300	120	At Least Two Kitchen Appliance Circuits	20A	2 or more	
COFFEEMAKER	1000	120				
REFRIGERATOR	300	120	2 #12	20A	2	Separate circuit serving only refrigerator and freezer is recommended.
FREEZER	350	120	2 #12	20A	2	

heavy-duty receptacles for electric ranges, dryers, etc.

Layout of Receptacles

General-purpose convenience receptacles of the duplex type should be laid out around the perimeters of living room, bedrooms and other general living areas. Spacing of receptacle outlets should be such that no point along the floor line in any usable wall space is more than 6 ft from a receptacle outlet in that space. Care should be taken to provide receptacle outlets in smaller sections of wall space segregated by doors, fireplaces, bookcases or windows. In hallways, convenience receptacles should be spaced to provide at least one for each 20 ft of wall length.

Convenience receptacles in kitchen, utility or work shop areas should be spaced even closer—one every 4 ft behind work counters and benches. Spacing of receptacle outlets in dining rooms can be 12 ft between receptacles.

Other convenience receptacles should be laid out for specific areas of the home—the bathroom, the pantry, refrigerator alcove and laundry area. Only grounding type outlets should be installed in laundry rooms, open porches, breezeways, basements, cellars, work shops, garages, on the exterior surfaces of outside walls or in like locations where the outlet may supply equipment used by persons standing on the ground or on grounded conductive materials. Number and positioning of these outlets must be determined by the designer in accordance with the particular architectural layout of the areas and with the nature of the work or activity involved.

Over and above general-purpose outlets and convenience receptacles, special-purpose outlets must be laid out to serve large known or anticipated appliances. The exact number of these outlets will vary with extent of electrical utilization.

Special-purpose outlets must be provided for such appliances as electrical cooking appliances, electric clothes washers, electric dryers, electric ironers, dishwashers, food waste disposal units, water heaters, space heaters, air conditioners, heat pumps, fuel-fired heating units and other specific load devices. These appliances and devices should be either plug-connected to their supply circuits or direct-

connected, as indicated in the accompanying table of residential circuits.

Modern Circuits

Circuits used to supply residential electrical loads may be divided into six basic types as follows:

1. **120-VOLT GENERAL PURPOSE CIRCUIT**—two No. 12 wires—has maximum design capacity of 2000 watts. Circuits of this type must be provided to handle the load of fixed lighting units throughout the house and the general-purpose convenience receptacles in areas other than the kitchen, dining, pantry, breakfast room, utility or laundry areas.

2. **120-VOLT APPLIANCE CIRCUIT**—two No. 12 wires—has maximum design capacity of 2000 watts. At least two such circuits must be provided to handle the appliance load in the kitchen and dining areas. All receptacles in these areas must be connected to such a circuit, excepting clock outlets.

3. **120-VOLT SPECIAL PURPOSE CIRCUIT**—two No. 12 wires—has maximum design capacity of 2000 watts. This type of circuit is used to serve a single outlet (plug- or permanently-connected) for an individual appliance or load device.

4. **240-VOLT SMALL CIRCUIT**—three No. 12 wires—has maximum design capacity of 4000 watts. This is a special-purpose circuit to serve an individual equipment load which is rated at less than 16 amps at 240 volts.

5. **240-VOLT MEDIUM CIRCUIT**—three No. 10 wires—has maximum design capacity of 6000 watts. This is a special-purpose circuit to serve an individual equipment load which is rated from 16 to 24 amps at 240 volts.

6. **240-VOLT LARGE CIRCUIT**—three No. 6 wires (neutral may be smaller)—has maximum design capacity of 10,000 watts. Or three No. 8's can be used for individual loads up to 7500 watts. This is a special-purpose circuit to serve one or more electric cooking appliances rated from 24 to 44 amps at 240 volts.

These circuits are presented in this form to afford

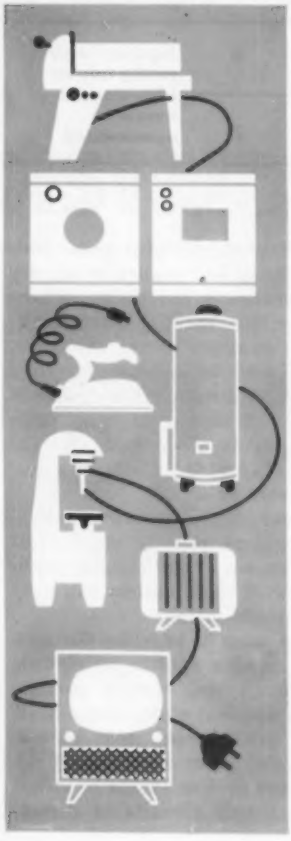
Grounding Type Convenience Receptacles In Residential Occupancies

(proposed for 1959 National Electrical Code)

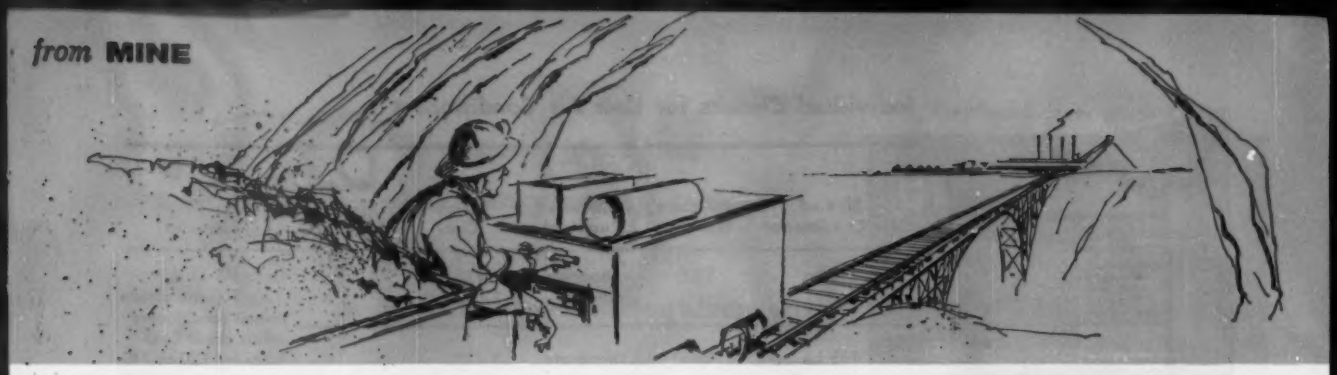
Change third sentence of section 2124b to read:

"Only grounding type outlets shall be installed in laundry rooms, open porches, breezeways, basements, cellars, work shops, garages, on the exterior surfaces of outside walls or in like locations where the outlet may supply equipment used by persons standing on the ground or on grounded conductive materials."

Modern Circuits for Appliance Loads



Load Devices	Typical Load in Watts	Volts	Wires	Circuit Breaker or Fuse	Number of Outlets	Notes
			for Laundry Areas			
IRONER	1650	120	2 #12	20A	1	Grounding type receptacle required.
WASHING MACHINE	1200	120	2 #12	20A	1	Grounding type receptacle required.
DRYER	5000	120/240	3 #10	30A	1	Appliance may be direct connected—must be grounded.
			for Other Loads			
HAND IRON	1000	120	2 #12	20A	2 or more	
WATER HEATER	3000					Consult Utility Co. for load requirements
WORKSHOP	1500	120	2 #12	20A	2 or more	Separate circuit recommended.
PORTABLE HEATER	1300	120	2 #12	20A	1	Should not be connected to circuit serving other heavy duty loads.
TELEVISION	300	120	2 #12	20A	2 or more	Should not be connected to circuit serving appliances.



to **YOU**

ONE SURE SOURCE OF SUPPLY

for all your wire and cable needs

Quality products, ample stocks, dependable deliveries—that's what you get when you work through a Circle distributor.

Quality products—because Circle controls every step in manufacturing—from the copper, lead, and zinc mined and refined by Cerro de Pasco down to the finished wire and cable—

Ample stocks—because Circle is one of the country's largest producers with over a billion feet of quality building wire and cable rolling out of its huge plants yearly—

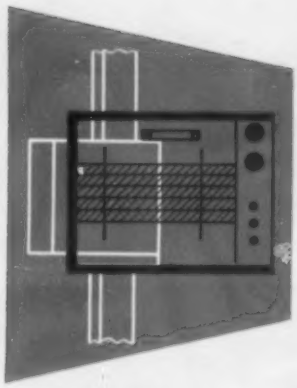
All-out service—because that's a basic policy at Circle, a policy which has earned Circle its reputation for giving fast, friendly, dependable service where and when it's needed.

Why don't *you* make a Circle distributor your "one sure source of supply." Many other satisfied contractors do.

C W C **CIRCLE** **WIRE & CABLE**
a subsidiary of
CERRO DE PASCO CORPORATION

PLANTS: Maspeth and Hicksville, N. Y. **SALES OFFICES & WAREHOUSES:** in all principal cities

RUBBER COVERED WIRES & CABLES • VARNISHED CAMBRIC CABLES • PLASTIC INSULATED CABLES
NEOPRENE SHEATHED CABLES • "CIRTUBE" EMT



Individual Circuits for Unit Air Conditioners

Size of Air Conditioner	Average Wattage	Circuits Required	Size of Circ.	Number of Outlets	Remarks
¾ hp	1200	Separate Circuit	2 #12 120-v	1	Use of 3-wire, 120/240-volt circuits to unit conditioners offers circuit flexibility for 120 or 240 volts
1½ hp	2400	Separate Circuit	3 #12 120/240-v	1	

a quick and ready way to think of circuit requirements. The circuits may vary somewhat from the indicated makeup for particular applications and depending upon the type of wire or cable assembly used for the circuiting. Ground wires must be added where necessary, and the use of 3-wire circuits instead of multiple 2-wire circuits—such as a single, 3-wire 120/240-volt circuit for two kitchen appliance circuits—offers wiring economy in many cases.

The design ratings given are based on 80% loading of circuits to assure minimum voltage drop on long circuits and to provide a measure of spare capacity. Best design practice dictates the use of 50% fixed and regular-duty loading of general-purpose circuits to allow full and flexible use of plug-connected portable appliances which are used for short but continuous periods—like hair dryers, pants pressers, electric hand irons, bottle warmers, vacuum cleaners and similar work appliances.

Circuit Requirements

The requirements for branch circuiting—as set forth early in this manual—cover sizing of circuit conductors, selection and sizing of overcurrent protective devices (selected with the panelboard to be used) and loading of circuits. Depending upon the general lighting load, the number of general-purpose receptacle outlets and the number and types of electrical appliances to be used, circuits can be laid out on the plans—using standard symbols to show the various circuits, outlets, switch legs, home runs and other data essential to properly inform the installer of the finished system the designer has in mind.

At least one 120-volt general-purpose circuit should be allowed for each 500 sq ft (or fraction thereof, of floor space in the house (excluding porches, etc.). This works out to 4 watts per-sq-ft

Sizing Service Entrance For A Modern Home

1. Calculate the load of general lighting and general-purpose receptacle outlets—to be served by 120-VOLT GENERAL PURPOSE circuits. For each 500 sq ft of floor area in the house (excluding porches, garages, unused spaces and unfinished areas, etc.), allow one such circuit. Allow an extra circuit for any part of 500 sq ft left over. Multiply the required number of circuits by 2000 to get the total load in watts. (It should be noted that the same figure could be arrived at by multiplying the total square feet of floor area by 4 watts per-sq-ft.)
2. Add the total circuit capacity—in watts—allowed for the appliance load in the kitchen, dining room, pantry, laundry and utility area, to be served by 120-VOLT APPLIANCE circuits. This watts total can be obtained by multiplying the number of such circuits laid out in branch circuit design by 2000. Or an assumed load of 4000 watts (two appliance circuits) can be used when the exact number of such circuits is not known.
3. Take 3000 watts of the sum of Steps 1 and 2 at 100% demand.
4. Add to this figure 35% (demand) of the remainder from the first three steps.
5. The sum of Steps 3 and 4 is the amount of capacity which must be provided in the service entrance conductors to supply the general lighting and general-purpose receptacle loads.
6. Add 8000 watts for an electric range (not over 12-kw rating). If the electric cooking appliances consist of a built-in oven and range top(s), Table 29 in Chapter 10 of the code must be consulted to get the proper demand load.
7. Add together the rated watts of all fixed appliances to be served by individual circuits not previously accounted for in the calculation. If both electric heating and air conditioning are to be used in the house, the rating in watts of only the larger of the two loads need be used in this total. This is due to non-simultaneous use of the two facilities.
8. Get the total of: the general lighting and general-purpose receptacle load (from Step 5); the electric range demand load (from Step 6); and 100% of the sum of fixed appliance loads (from Step 7).
9. Divide this grand total of watts by 240 (for 120/240-volt, 3-wire, single-phase service) to get the required ampere rating of the service conductors.
10. From Table 1 in Chapter 10 of the Code, select the size of conductors which have the required current-carrying capacity. Table 4 in Chapter 10 gives the required size of conduit to carry the service entrance conductors.

IT PAYS TO HAVE GOOD CONNECTIONS — HUBBELL

a complete line of quality wiring devices to meet 1959 Electrical Code Requirements

15 Amps., 125 Volts

5262
Duplex, Brown
Specification Grade

5261
Single, Brown
Specification Grade

COMBINATION

5292
Duplex, Brown
Specification Grade

15 Amps., 125 Volts

15 Amps., 250 Volts

15 Amps., 250 Volts

15 Amps., 250 Volts

5662
Duplex, Brown
Specification Grade

5661
Single, Brown
Specification Grade

"TWIST-LOCK" FOR GROUNDING ONLY

15 Amps., 125 Volts — 15 Amps., 277 Volts

4700
Duplex, Brown
Specification Grade

4710
Single, Brown
Specification Grade

4750
Duplex, Brown
Specification Grade

4760
Single, Brown
Specification Grade

Continued from page 110

engineering news

HARVEY HUBBELL, INCORPORATED
Engineering Department

Based on these findings, the IAEI, at their annual meeting in 1947, made recommendations which resulted in a new code for grounding portable equipment at the 15 ampere level and below. Their solution for cause #1, the "pigtail", was simple and obvious; namely, abolish "pigtail" grounding entirely. *Supply cords on equipment rated 125 volts or less would be furnished with a male cap having the same number of male blades as there are conductors in the cord.*

Regarding accident cause #2, plugging into 3-phase circuits could be prevented by designing a grounding attachment plug cap so that the *grounding blade would be shaped differently than that furnished with any other grounding plug cap in existence*. The new design would be furnished grounded only. In other words, the grounding member would always be connected *mechanically* and *electrically* to the metal armor or shell and not dependent on the user to connect the grounding means.

Lastly, for accident cause #3, it was decided to eliminate the "dual" voltage ratings found on almost all standard commercial wiring devices. As a result,

it would be impossible to insert a male 2-wire cap furnished on an appliance into a receptacle wired for 250 volts. All devices with parallel blades, slots or contacts would be singly rated at 15 amperes, *125 volts only*, and all devices with tandem blades, slots or contacts would be singly rated at 15 amperes, *250 volts only*. The new device, then, would be in two styles: "A", parallel slots and U-shaped ground blade, rated at 15 amperes, 125 volts and "B", tandem slots and U-shaped ground blade, rated at 15 amperes, 250 volts.

HARVEY HUBBELL, INCORPORATED
BRIDGEPORT 2, CONNECTICUT

WIRING DEVICE OFFICE AND WAREHOUSE LOCATIONS

Bridgeport 2, Connecticut
State and Bostwick Streets

Chicago 7, Illinois
37 South Sangamon Street

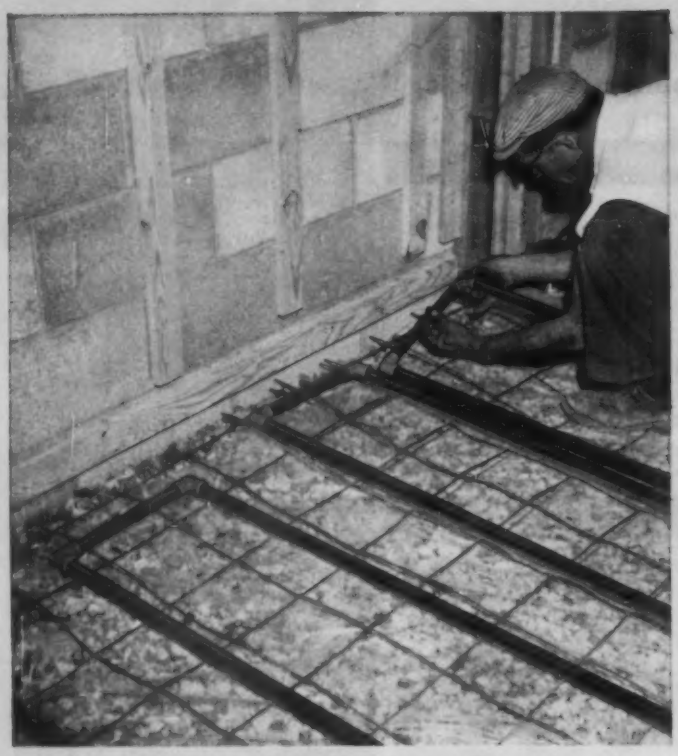
Los Angeles 12, California
103 North Santa Fe Avenue

San Francisco, California
1675 Hudson Avenue

IN CANADA:
Scarborough, Ontario,
1160 Birchmount Road

Have you seen our March Engineering News article on the subject of Grounding *Only* Twist-Lock"? Copy on request.

Naugatuck KRALASTIC®
Rubber-Resin



Installation of KRALASTIC pipe manufactured by Plastic Pipe Division, Triangle Conduit & Cable Co., Inc.

Whole sections are easily prefabricated and carried to site.

Solvent welding speeds and simplifies connections.

Now Kralastic reduces radiant heating costs

PROVED FOR 8 YEARS—1½ MILLION FEET IN USE

KRALASTIC®—the plastic pipe material that has proved so superior in dozens of piping applications—has now made it possible to reduce overall radiant heating costs by an average of 25% ... as much as 25 cents a square foot!

Thoroughly approved by all who have worked with it, including architects, heating engineers, and contractors, KRALASTIC has made radiant heating practical for home buyers and builders everywhere by providing such advantages as these:

- Lower cost than any metallic coil material on the market
- Lightweight toughness that allows whole grid sections to be prefabricated in the shop
- Solvent welding for quick, sure joining on the job
- No need for special expansion joints as with other materials
- Exceptional resistance to clogging
- Complete freedom from rust and corrosion
- Compatibility with standard radiant heating designs and techniques

The more than 145 installations of KRALASTIC for radiant heating give evidence of the advantages you can expect in KRALASTIC pipe for potable water supplies, chemical piping, electrical conduit, waste disposal, applications by the hundreds. Learn first hand the proved advantages this tough rubber-resin material offers *you*. For further information on KRALASTIC pipe, for expert technical assistance with *any* product application, contact us today.

United States Rubber
Naugatuck Chemical Division
534K ELM STREET
NAUGATUCK, CONNECTICUT

KRALASTIC RUBBER-RESINS • **MARVINOL** VINYLS • **VIBRIN** POLYESTERS

Akron · Boston · Gastonia · Chicago · Los Angeles · Memphis · New York · Phila. · CANADA: Naugatuck Chemicals · Elmira, Ont. · Cable: Rubexport, N.Y.

of floor area. And this is circuit capacity for general lighting and general-purpose receptacle outlets. This much capacity is a minimum recommended amount.

In some cases, the use of extensive general lighting and special lighting effects throughout a house will require greater circuit capacity for the load. In such cases, the loads should be broken down and circuited carefully to assure proper loading of circuits.

The total general load from above must be divided among the number of general-purpose circuits used, laying out back-to-back outlets in interior partitions and utilizing 3-wire circuits to split-wired receptacles to effect balanced loading. By laying out each circuit to serve a few of the outlets in each of several rooms, conforming actual positioning of receptacle outlets to keep each circuit lightly loaded when heavy utilization exists in a single room, the possibility of overloading either side of the 3-wire system can be virtually eliminated.

Quick Calculation of Service Capacity

A simplified method of calculating size of service entrance conductors and equipment is presented in the recently issued FHA Minimum Property Standards. Although this method provides a minimum size of service, it can be adapted to sizing service entrances in accordance with recommended standards as follows:

1. Required capacity of service entrance may be computed by summing individual demand loads, as applicable for the particular installation, from this table:

	Diversified demand (KW)
Basic demand	4.0
Automatic clothes washer	.6
Dishwasher	.9
Electric range	8.0
Electric oven, built-in	3.6
Electric cooking top, built-in (4 units)	4.5
Electric clothes dryer:	
Normal	3.4
High speed	6.3
Electric water heater:	
High recovery	3.4
Normal recovery	1.5
Food freezer	.6
Food waste disposer	.4
Water pump	.4
Attic fan	.4
Electric bathroom heater (each)	1.3
Central heating system (fuel-fired)[1]	.5
Room air conditioner (each)	1.0
Central air conditioner[1]	[2]

[1] Only the larger of the heating or cooling load need be considered.
[2] Rated kilowatts.

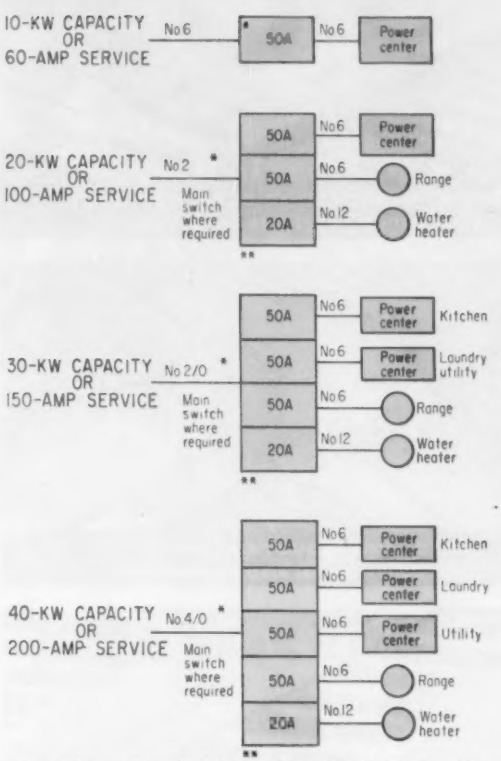
2. Minimum size of conductors and equipment for service must conform to the total computed demand load:

A. For loads up to 10-kw demand, use a No. 6 service.
B. For loads over 10-kw but not more than 20-kw demand, use a No. 2 service.
C. For loads over 20-kw demand, use a larger service, sized according to the procedure given in an accompanying table.

NOTE: See accompanying illustration "Recommended Service Layouts for Residential Systems."

Recommended Service Layouts for Residential Systems

(120/240-volt, 3-wire service)



* Main switch may be omitted if six or less main control center units are used serving local power center panels
** Main control center units may be omitted if main switch is used serving one power center panel

Appliance Circuits

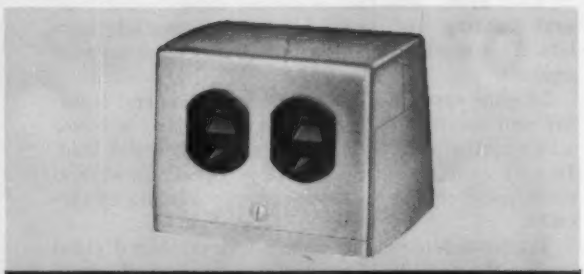
In the kitchen and dining room areas (including the pantry and breakfast room), at least two 120-volt appliance circuits must be provided. One or more such circuits must also be provided for the laundry area, depending upon the location and the total load; and the utility or work room should have one or more circuits of this type. Other appliance circuits are described on the previous pages.

Other circuit requirements for a typical house are given in accompanying tables which cover complete data for each type of appliance or device.

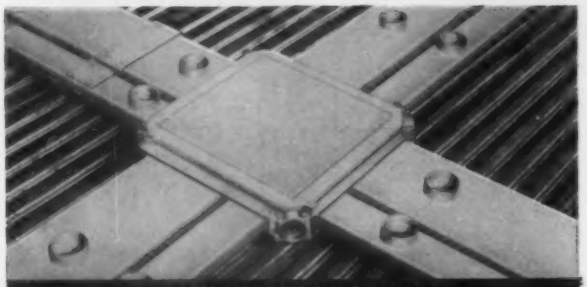
Service Entrance

Calculation of the size of service entrance conductors and layout of the service equipment and distribution equipment (either a single load center in the basement or garage, combined with or adjacent to the service equipment, or one or more local power centers on the upper floors of the house in addition to the service entrance panelboard) are made from study of the load and branch circuit provisions. Two procedures for sizing service entrances are given in this section. These procedures are not substitutes for engineering design of the branch circuit system supplied from the service entrance.

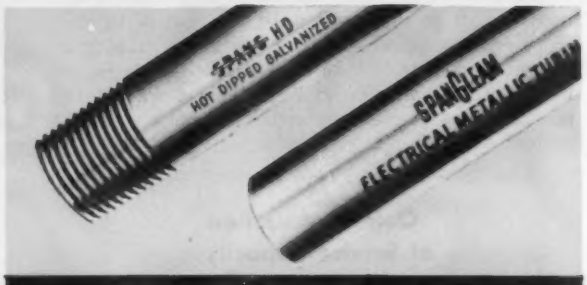
SPANG STANDARD UNDERFLOOR DUCT
for conventional slab construction



SPANG UNDERFLOOR DUCT SERVICE FITTINGS
for every type outlet



SPANG INDUSTRIAL DUCT
for conventional slab construction



SPANG RIGID CONDUIT AND EMT
in a complete range of sizes

SPANG HEADERDUCT
for use with cellular floor construction

SPANG CONDUIT FITTINGS
packaged for your convenience

SPANG GIVES YOU TOP-QUALITY WIRING PROTECTION

WITH SPANG UNDERFLOOR DUCT SYSTEMS

Your choice of three systems to suit your construction requirements. New engineered design permits fast, time-saving installations. Lightweight, square aluminum junction boxes provide easy handling, maximum working area. Complete line of fittings available in high-lustre brass or aluminum finish.

WITH SPANG CONDUIT AND FITTINGS

Your choice of hot-dipped galvanized rigid conduit and elbows with electro-galvanized couplings, or lightweight electrical metallic tubing. Quality-controlled during manufacturing to assure uniformity and easy installation on the job. Tested and inspected before shipping.

AVAILABLE THROUGH YOUR SPANG DISTRIBUTOR

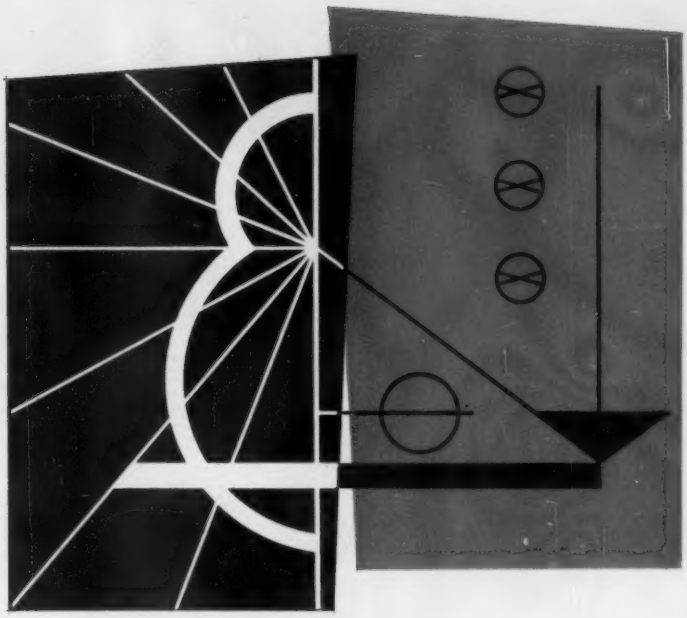
SPANG Underfloor Duct and SPANG Conduit are sold by over 500 electrical distributors from coast to coast. The SPANG Distributor in your area will give you *top-quality* service on all your electrical material requirements. Let him work with you on your next job. And be sure you ask for SPANG!

SPANG CONDUIT AND UNDERFLOOR DUCT

THE NATIONAL SUPPLY COMPANY

Subsidiary of Armco Steel Corporation

TWO GATEWAY CENTER, PITTSBURGH, PA.



A 10-Step Procedeure for . . .

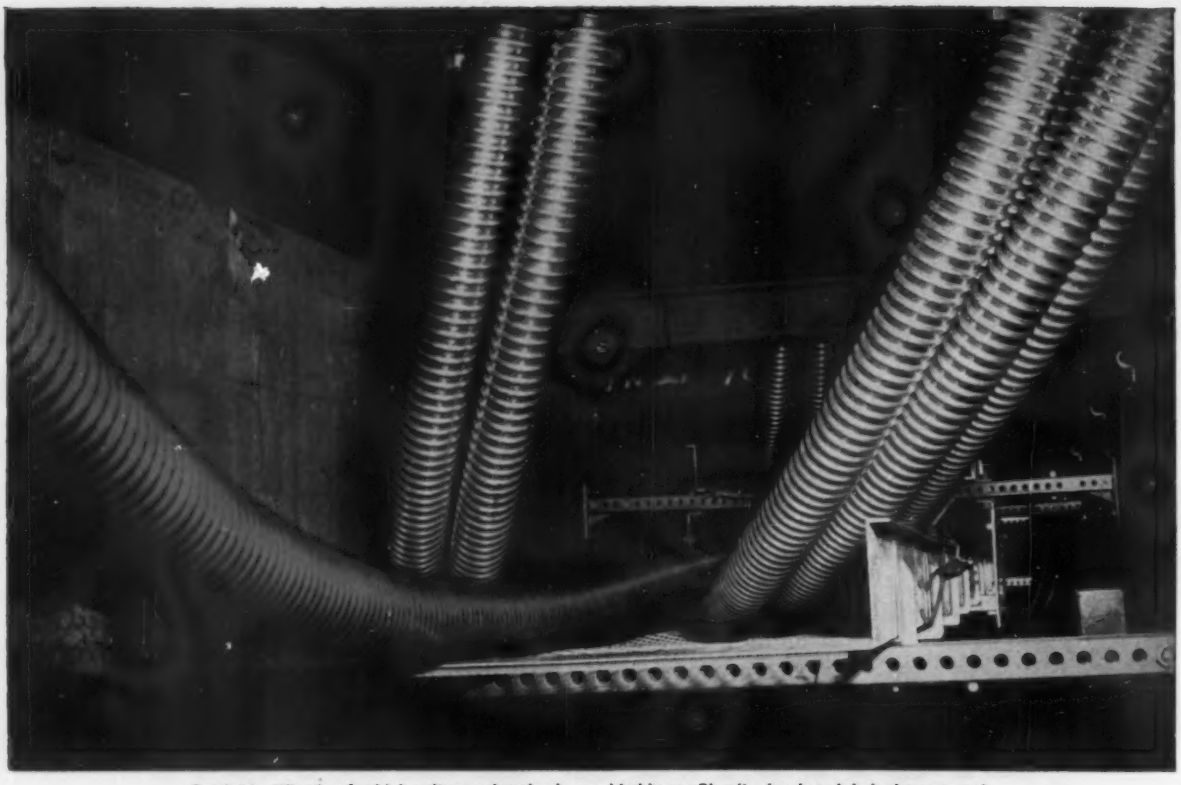
LIGHTING DESIGN

Step 1 Analyze the Lighting Problem
Step 2 Select Needed Lighting Levels
Step 3 Determine Desired Lighting Quality
Step 4 Select Proper Light Sources
Step 5 Select Appropriate Lighting System
Step 6 Make a Lighting Calculation
Step 7 Prepare the Lighting Layout
Step 8 Provide Flexible Control of System
Step 9 Analyze Available Systems of Electrical Circuits
Step 10 Check Proposed Lighting System for Practicality

THE design of modern lighting systems is not overly complicated, when practical procedures are adopted and carefully followed. However, the art and science of lighting is much broader in scope, and requires a far greater knowledge and understanding of the physics and control of light, the science of seeing, the principles of architectural and structural building design, artistic values, the myriad light sources, lighting equipments and components and related factors, than is generally recognized.

Presented here is a detailed procedure for the design of modern lighting systems. It has been simplified by breaking the problem down into ten separate parts, or steps. Some of the many factors to be considered under each step have been listed, and some of the decisions to be made have been spelled out in detail.

The lighting designer should supplement this 10-step practical approach to lighting design with a lighting reference library selected to meet his own particular requirements. Some typical references on lighting technology have been suggested in the following pages.



Quick identification for high voltage primaries is provided by an Okonite-developed, baked-on enamel finish in bright orange. In this access tunnel below transformer enclosure 3/c 15kv Okonex primaries are laid in same tray with 3/c 600v Okonex secondaries with plain aluminum Loxarmor. Plant and electrical system were engineered and designed by Southwestern Engineering Company. Electrical contractors were Trowbridge & Flynn Electric Company.

"Power supply is vital," said Diamond Gardner Corp. "We furnished Okonite cables," said Del E. Webb and SWECO

Here was an ultra-modern, completely integrated manufacturing operation where power failures could trigger a costly "chain reaction" in down time. That's one reason why Del E. Webb Construction Company and Southwestern Engineering Company furnished Okonite cables for extensive use in the new and unique mechanical pulping mill for Diamond Gardner Corporation's Integrated Forest Products Center at Red Bluff, California.

Another reason was SWECO's knowledge that The Okonite Company, because it alone makes cables by all methods, is uniquely qualified to help select the best cable for a specific circuit . . . and manufacture it to suit any installation conditions.

All primary and secondary power and control circuits in the plant are Okonite cables. For example: lightweight Okonex-insulated Loxarmor primaries, identified by an Okonite-developed bright orange, baked-on enamel finish, carry all power at 12kv to the twin transformer vaults in the plant. 600-volt Watertite-Loxarmor, 600-volt Okonex-Loxarmor and 5kv Okonex-Loxarmor, in racks, were selected for secondary distribution for their flexibility, low installation costs and the ease with which circuits can be added or re-routed. 600-volt Okotherm control cables were specified for circuits where high heat conditions are encountered.

Okonite quality . . . Okonite's ability to build cables by any method . . . and Okonite's expert design and installation assistance are factors to consider when ordering or specifying cables for your important installations. For more data on Loxarmor, write for free, 36-page Bulletin EC-1090, The Okonite Company, Passaic, New Jersey.

where there's electrical power . . . there's **OKONITE CABLE**

6214

Step 1. Analyze the Lighting Problem

Quite logically, the first thing to do in planning a lighting system is to determine, to the extent possible, exactly what the lighting problem is. In general, the lighting problem is dictated by four major factors. 1) physical size and shape of the area; 2) architectural design and structural details; 3) occupancy or end use, of the area; and 4) the type and degree of severity of the seeing tasks which will exist. Inherent in these will be other allied sub-factors, such as: type of environment—dictated by type of occupancy; extent of use of glass facades—dictated by architectural design; etc.

Physical dimensions—Determine the exact size and shape of the area to be lighted. On small projects, this may be a simple single area, defined by width, length, and ceiling height. On larger projects, it will usually consist of an area which can be subdivided into a number of simple individual areas, and each defined separately. Complete area dimensions should be tabulated, and further supported by plan and elevation drawings, when available.

Structural details—Determine the architectural design and structural details. On new projects, these details should be available on architectural and structural drawings, or from the architect or builder. On relighting projects, a visit to the job should be made, and all details noted.

Occupancy—Determine what the area will be used for, and how it will be utilized. For example, if it is to be used for manufacturing, obtain a firm (or tentative, if necessary) layout of departments, machinery, production lines, etc., and a description of type of work which will be done in each department, or area.

Seeing tasks—Determine, and tabulate, the various types of seeing tasks which will exist in the area, or areas. Type of occupancy, layout of the area, and type of work to be done will dictate the type of seeing problems which will be encountered.

Add to the above information any other details that can be determined, such as: ceiling, wall, and floor construction; color and finish of ceiling, walls, and floors; location, size and shape of any columns or other structural details, etc; whether the area will be air conditioned, and type, size, and location of air ducts, diffusers, etc; and other similar details.

Step 2. Select Levels of Illumination

In 1958, the Illuminating Engineering Society approved and announced a complete revision of their Recommended Levels of Illumination. These new footcandle values are based on a new system of determining illumination level recommendations which has been adopted by the Society. The new system, in turn, is based on the results of light and vision researches conducted by Dr. H. Richard Blackwell at the Vision Research Laboratories of the University of Michigan, under the sponsorship of the Illuminating Engineering Research Institute, an IES-sponsored research organization, and earlier light and vision work.

The new IES recommended lighting levels are, in general, considerably higher than had been in effect previously. These lighting levels have been expressed in footcandle values for a long list of seeing tasks which exist in commerce, industry, and the home. They are included in detail in new Footcandle Tables, published in the new 1959 third edition of the *IES Lighting Handbook*. They are also shown in condensed form in the accompanying "New IES Recommended Illumination Levels" chart.

Current and future lighting system design should now be based on the new IES recommended lighting levels, according to the seeing tasks involved.

The new lighting levels, it should be noted, are now based on seeing task brightness values, in which values of equivalent contrast, from the research data, were divided into five categories or general levels of seeing task difficulty. These categories are listed in the table "Visual Task Brightnesses and Related Lighting Levels". The first category represents contrast values which require task brightness values of less than 18 footlamberts. The range of contrast values requiring more than 18 footlamberts was divided into four equal categories in terms of contrast values.

The chart "Brightness and Lighting Level Relationship" shows the required illumination levels for visual tasks designated "Difficult," with visual task brightnesses ranging from 42 to 120 footlamberts, and visual task reflectances ranging from 5 to 95%. Similar charts may also be developed for the other four visual task categories. Note that footcandle levels for visual tasks having

Visual Task Brightnesses and Related Lighting Levels

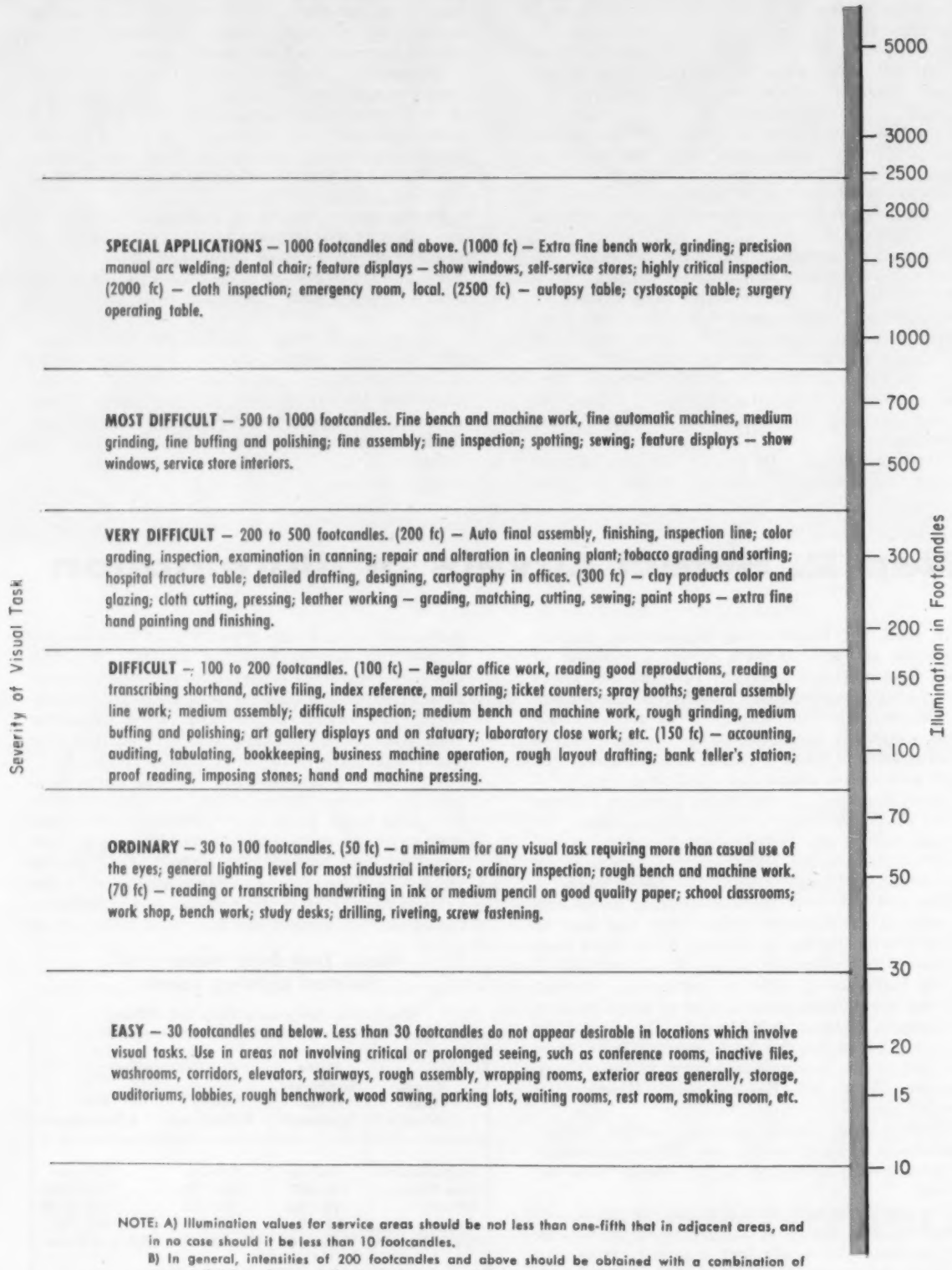
(For General Categories of Visual Task Difficulty)

Visual Task Difficulty	Guide Brightness (Footlamberts)	Footcandles*	
		60% Reflectance	6% Reflectance
Most Difficult..	420 up	700 up	7000 up
Very Difficult..	120–420	200–700	2000–7000
Difficult.....	42–120	70–200	700–2000
Ordinary.....	18–42	30–70	300–700
Easy	Below 18	30 and below	300 and below

*Footcandles depend upon reflectance of the visual task.

New IES Recommended Illumination Levels

Typical Visual Tasks


Severity of Visual Task
Illumination in Footcandles
5000
3000
2500
2000
1500
1000
700
500
300
200
150
100
70
50
30
20
15
10
SPECIAL APPLICATIONS — 1000 footcandles and above. (1000 fc) — Extra fine bench work, grinding; precision manual arc welding; dental chair; feature displays — show windows, self-service stores; highly critical inspection. (2000 fc) — cloth inspection; emergency room, local. (2500 fc) — autopsy table; cystoscopic table; surgery operating table.
MOST DIFFICULT — 500 to 1000 footcandles. Fine bench and machine work, fine automatic machines, medium grinding, fine buffing and polishing; fine assembly; fine inspection; spotting; sewing; feature displays — show windows, service store interiors.
VERY DIFFICULT — 200 to 500 footcandles. (200 fc) — Auto final assembly, finishing, inspection line; color grading, inspection, examination in canning; repair and alteration in cleaning plant; tobacco grading and sorting; hospital fracture table; detailed drafting, designing, cartography in offices. (300 fc) — clay products color and glazing; cloth cutting, pressing; leather working — grading, matching, cutting, sewing; paint shops — extra fine hand painting and finishing.
DIFFICULT — 100 to 200 footcandles. (100 fc) — Regular office work, reading good reproductions, reading or transcribing shorthand, active filing, index reference, mail sorting; ticket counters; spray booths; general assembly line work; medium assembly; difficult inspection; medium bench and machine work, rough grinding, medium buffing and polishing; art gallery displays and on statuary; laboratory close work; etc. (150 fc) — accounting, auditing, tabulating, bookkeeping, business machine operation, rough layout drafting; bank teller's station; proof reading, imposing stones; hand and machine pressing.
ORDINARY — 30 to 100 footcandles. (50 fc) — a minimum for any visual task requiring more than casual use of the eyes; general lighting level for most industrial interiors; ordinary inspection; rough bench and machine work. (70 fc) — reading or transcribing handwriting in ink or medium pencil on good quality paper; school classrooms; work shop, bench work; study desks; drilling, riveting, screw fastening.
EASY — 30 footcandles and below. Less than 30 footcandles do not appear desirable in locations which involve visual tasks. Use in areas not involving critical or prolonged seeing, such as conference rooms, inactive files, washrooms, corridors, elevators, stairways, rough assembly, wrapping rooms, exterior areas generally, storage, auditoriums, lobbies, rough benchwork, wood sawing, parking lots, waiting rooms, rest room, smoking room, etc.

NOTE: A) Illumination values for service areas should be not less than one-fifth that in adjacent areas, and in no case should it be less than 10 footcandles.

B) In general, intensities of 200 footcandles and above should be obtained with a combination of general lighting plus specialized supplementary lighting, taking special care to keep within recommended brightness ratios (see table).

WHEELER-FULLERTON*
CUSTOM DESIGNS SPECIAL LIGHTS

FOR REQUIRED READING AT RUTGERS

*

Two 45 ft. suspended units provide soft, diffused shadowless light of 60 footcandles over the main book desk. A similar 45 sq. ft. unit is used over main reading room. Tapered birch wood sides, mounted on extruded aluminum channel, blend with library panelling.

Book stack units have acrylic plastic shields.

Meeting the varied requirements of efficient library lighting is a challenge that demands experience, skill and ingenuity. The Rutgers University Library presented special lighting problems. Illuminating the reading areas and book stacks, as well as providing safety, night and exit lighting, called for all of Wheeler-Fullerton's custom designing skill. The entire library installation of approximately 2,500 units combine high efficiency lighting and ease of maintenance with fixtures that blend harmoniously with the panelled decor.

WF

WHEELER • FULLERTON

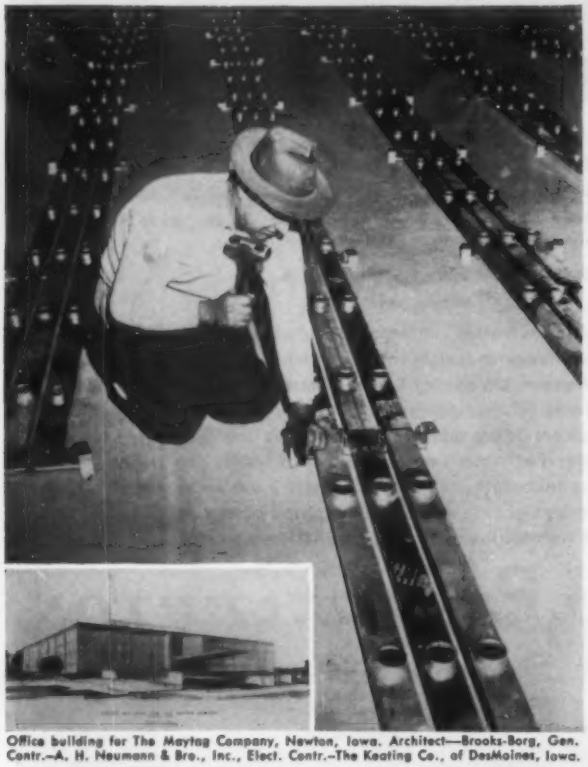
Lighting Division · Franklin Research Corp.

275 CONGRESS STREET, BOSTON 10, MASS.

Rutgers University Library, New Brunswick, New Jersey
Architects — York and Sawyer, New York
Electrical Engineers — Fred L. Morrell, Morrell Associates, New York, N. Y.
General Contractor — Caspers Construction Corp., Linden, N. J.

Modern Trend for Feeding and Distribution of...

UNDERFLOOR DUCT or HEADER DUCT



Office building for The Maytag Company, Newton, Iowa. Architect—Brooks-Borg, Gen. Contr.—A. H. Neumann & Bro., Inc., Elect. Contr.—The Keating Co., of DesMoines, Iowa.

Two Big Problems... ...and the answers!

QUESTION: *How close shall I space the distribution duct for complete coverage?*

REMARKS: The work area of a standard desk and chair takes a six foot square space.

ANSWER: With Duct on 3' center, the desk can be moved and turned in any direction and Inserts will always be available under the desk.

QUESTION: *How do I feed the System?*

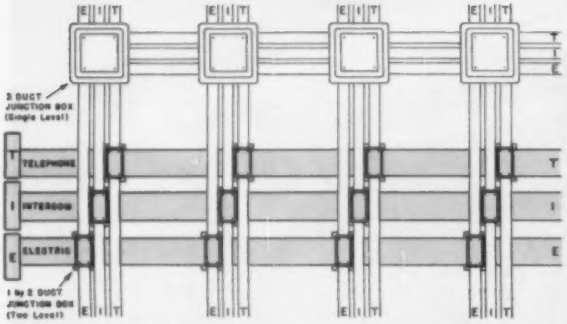
ANSWER: Feed with Duct . . . preferably Super Duct . . . directly to the cabinets or closets.

ANSWER: With the new Gateway boxes, any service can be fed independently of the others.

REMARKS: Remember . . . one Standard Duct will carry—legally—84 TW wires (#12) or 9 telephone cables (26 pair).
Super Duct will carry 207 TW wires (#12) or 24 telephone cables (26 pair).

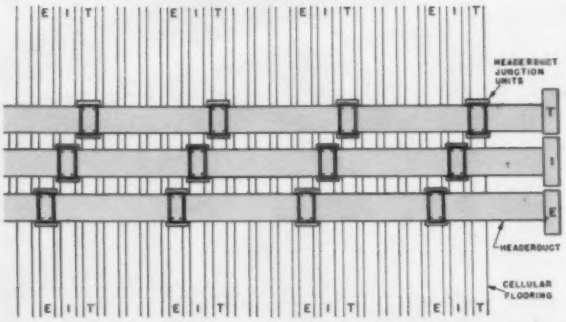
COMPARISON: 1¼" conduit will carry 9 wires (#12) or 3 telephone cables (26 pair).
Therefore, in comparison, using #12 TW wire:
1 standard duct = 9 conduits(1¼")
1 super duct = 23 conduits(1¼")
And with Telephone Cables (26 pair):
1 standard duct = 3 conduits(1¼")
1 super duct = 8 conduits(1¼")

UNDERFLOOR DUCT DISTRIBUTION for Concrete Slab Construction



The economy of single level underfloor systems can now be coupled with the good feeding possibilities with two level systems to meet the new requirements for three foot spacing between raceways and selective feeding for each electrical service.

HEADER DUCT FOR CELLULAR STEEL FLOOR Distribution Systems



Rectangular Boxes provide access to cells through grommeted openings to right or left of Headerduct. This speeds installation, fishing and pulling. Duct or Conduit take-offs are possible from any one of these Access Boxes.

SEE OUR CATALOG IN SWEET'S OR WRITE FOR COPY

GATE-WAY DUCT the Color-Code System

Stocked by Electrical Wholesalers in many locations throughout the U.S.A.

GATEWAY ENGINEERING CO.

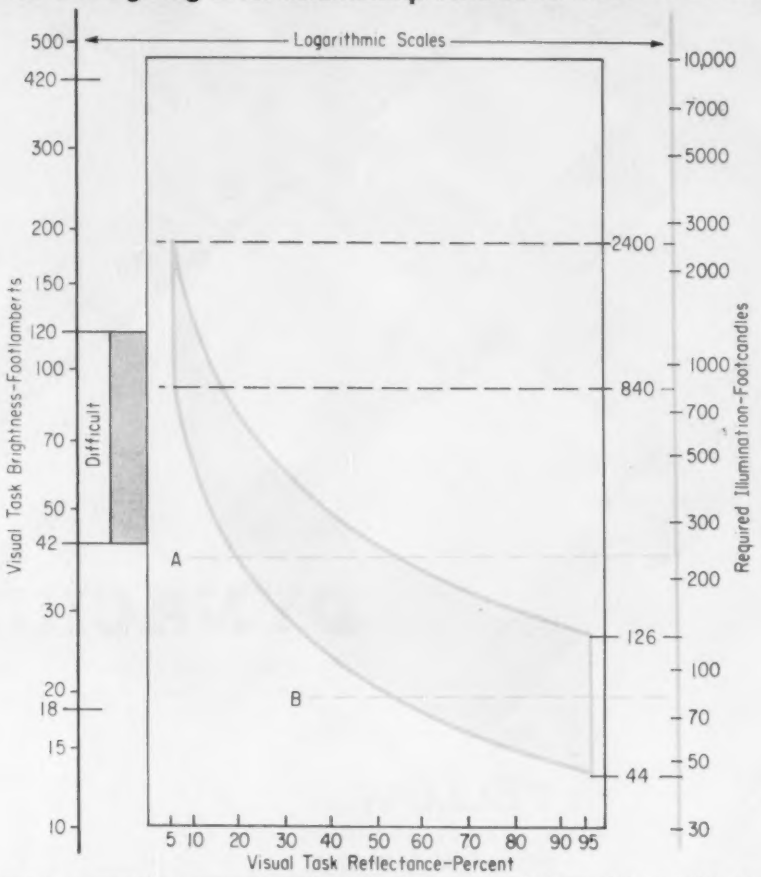
3233 West Grand Avenue • Chicago 51, Illinois

Representatives and Distributors throughout the U.S.A.

reflectance values ranging from about 30% to 80%, and probably representing those visual tasks most generally found in practice, fall between lines A and B, or between 100 and 200 footcandles. (In selecting illumination values for typical visual tasks, the IES technical committees fitted the values into the sequential order of 10, 15, 20, 30, 50, 70 and 100 times 0.1, 1, 10, 100 and 1000, as required. Thus calculated illumination values falling between about 75 and 225 were tabbed at 100, 150 or 200, according to the sequential order procedure).

New illumination values for residential lighting have been given in detail in the table titled "IES Recommended Illumination For Residences," shown on a following page.

Brightness and Lighting Level Relationship for Difficult Visual Task Category



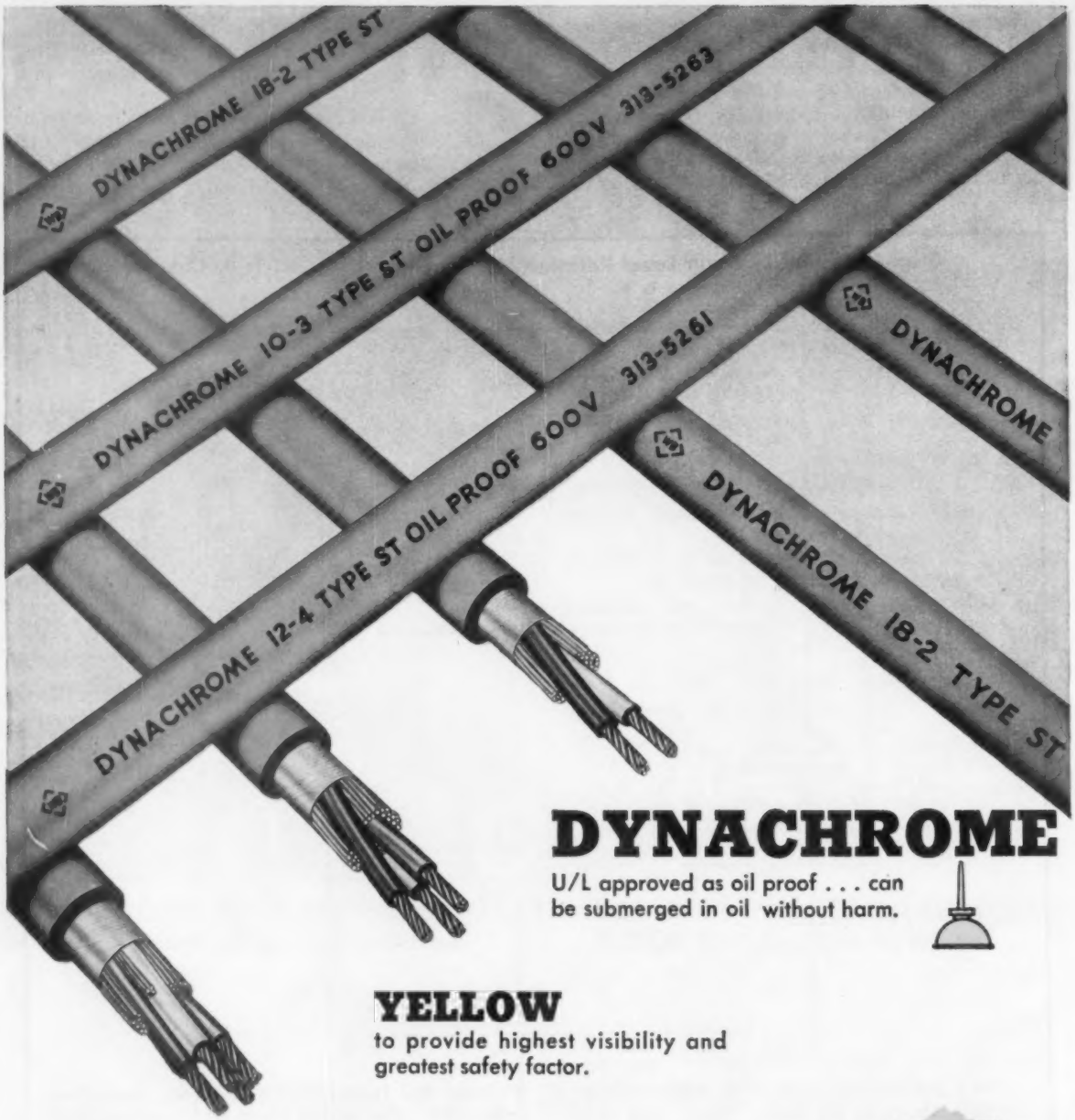
The above chart is a graphical representation of the data shown in the table "Visual Task Brightnesses and Related Lighting Levels," for seeing tasks classified as "Difficult." Visual task brightnesses are shown in the vertical scale at the left, in footlamberts. Also shown on the logarithmic scale are the brightness ranges for the other four categories of seeing task difficulty.

Visual task reflectance values are shown in percent on the bottom numerical scale, covering practical values ranging from 5% to 95%.

Required illumination for "difficult" visual tasks, or for visual tasks ranging from 42 to 120 footlamberts in brightness, and plotted against visual task reflectance values of 5% to 95%, are shown in the shaded area between the two curves, in footcandles. The footcandle values are plotted against a logarithmic scale (right). Note that footcandle values range from 44 to 126 at 95% visual task reflectance, and from 840 to 2400 at 5% visual task reflectance. The bottom curve is for seeing tasks with a visual task brightness of 42 footlamberts; top curve represents seeing tasks with a visual task brightness of 120 footlamberts.

The required illumination for the "very difficult" seeing task category, representing visual task brightnesses between 120 and 420 footlamberts, if plotted on this same chart, would form a shaded area immediately above that shown. Similarly, the required illumination for the "ordinary" seeing task category, representing visual task brightnesses between 18 and 42 footlamberts, if plotted on this chart, would form a similarly shaped shaded area immediately below the one shown.

Professional lighting designers might develop separate charts of this type, one for each seeing task category, for design reference. Or, if drawn to large scale, all data could be shown on one chart.


DYNACHROME 18-2 TYPE ST
DYNACHROME 10-3 TYPE ST OIL PROOF 600V 313-5263
DYNACHROME 12-4 TYPE ST OIL PROOF 600V 313-5261
DYNACHROME
DYNACHROME 18-2 TYPE ST

DYNACHROME

U/L approved as oil proof . . . can be submerged in oil without harm.

YELLOW

to provide highest visibility and greatest safety factor.

MARKED

clearly with type, size and number of conductors, as well as catalog number, all for easy identification.

Write today for new FREE catalog

Well Built Wires Since 1899

WHITNEY BLAKE COMPANY

NEW HAVEN 14, CONNECTICUT

TELEPHONE CHestnut 8-5515 TWX: NH84

Step 3. Analyze Lighting Quality

The problem of how to evaluate *quality* of light on a valid, scientific basis is under research and study by the Illuminating Engineering Research Institute. In the meantime, there is already considerable knowledge available relating to visual comfort and similar factors to provide practical guidance on lighting *quality* appraisal, based on past researches and field experiences.

In determining the *quality* of the light to be provided for a specific lighting design problem (or set of seeing tasks), there are several factors to be considered and analyzed. These include: 1) end use of the lighting result; 2) visual environment; 3) light control; and many others.

End Use of Lighting Result—Determine whether the light needed is for utilitarian use—light for seeing, or work light, so to speak; or for decorative use—light for decoration, as in a fine restaurant, or hotel lobby, etc. Often the light must be used for both utility (reading a menu in a restaurant, for example) and for decoration (to create a certain decorative effect and mood in the restaurant, for example). The end use of the lighting result will influence to considerable extent the quality of the light needed.

Visual Environment—Analyze the visual environment which is proposed (or which should be recommended by the lighting engineer). Factors which create or influence the visual environment include such items as the physical size of the area, the colors and finishes of the interior (floor, walls, ceilings, presence of glass walls, windows, doors, etc.), and size, colors and finishes of interior furnishings (machines, furniture, draperies, murals, etc.). All of these factors have an influence on the *quality* of the light; or, to look at it from a different viewpoint, the *quality* of the light can be controlled to create the type of visual environment which is desired. This *quality* may be controlled by the judicious selection of light sources, types of luminaires, and types and locations of lighting equipments in general.

Light Control—Visual tasks and lighting *quality* will influence the type of light control to be selected. In other words, the visual tasks and desired *quality* will dictate the choice of diffuse or directional light control, the degree of shielding needed, and similar features. Conceivably, many seeing tasks may call for a combination of light control principles—hence, for lighting equipment which incorporates several types of light control (diffusion, shielding, directional control, polarization etc., all in one luminaire).

Also inherent in light control is glare control. This includes the control or reduction of both direct and reflected glare. The commonly used system for glare appraisal is the Visual Comfort Index system. Thus many lighting equipment manufacturers now provide VCI values for specific luminaires, along with other technical data.

Other factors which affect lighting quality include the color quality of the light which is produced by the light sources, the brightness ratios (see table "Recommended Brightness Ratios for Interior Lighting") which result from the various colors and reflectance values, and other possible glare sources, such as sky glare, or glare from other sources such as windows or glass walls.

Recommended Interior Reflectances

Surface	Reflectance Range (%)
Ceiling	75-90
Upper Walls	40-65
Trim	30-50
Machines	30-40
Lower Walls	30-60
Furniture	25-40
Floors	15-30

Recommended Brightness Ratios for Interior Lighting

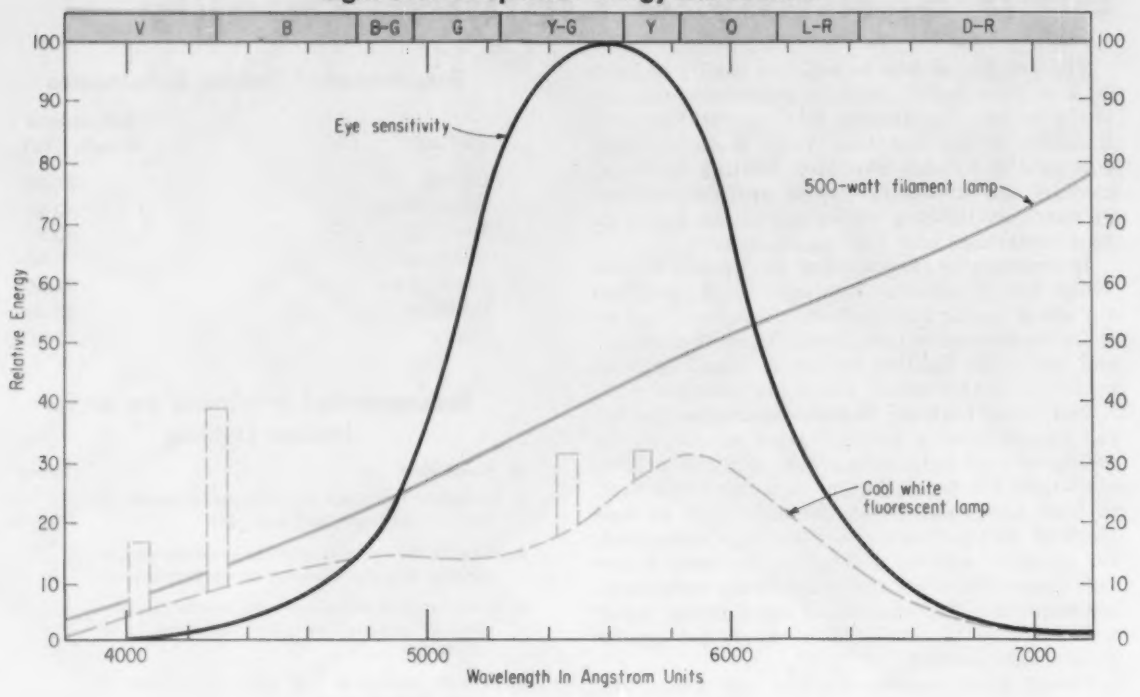
In Visual Field . . .	Ratios
a. Between visual tasks and adjacent surroundings (e.g.—white paper, and desk top)	1 to ⅓
b. Between visual tasks and more remote darker surfaces (e.g.—white paper on desk, and floor)	1 to 1/10
c. Between visual tasks and more remote brighter surfaces (e.g.—white paper on desk, and luminaires)	1 to 10
d. Between luminaires and adjacent surfaces in normal field of view	20 to 1
e. Anywhere within normal field of view (e.g.—between luminaires and floor)	40 to 1

Step 4. Select Proper Light Source

The heart of any lighting system is the light source, or sources, which convert electric energy into light. The efficiency of the light source, measured in lumens per watt, dictates to considerable extent the overall efficiency for the lighting system in which it is used. It is therefore highly important that the lighting engineer select the light sources for his lighting systems with intelligence and care.

Light source efficiency is not the only factor to be considered, of course. Other factors include such features as color quality of the light (spectral quality), total light output of the lamp, lamp life, lumen depreciation throughout life, stroboscopic effect, amount of heat produced, effect of ambient temperature surrounding the lamp on its efficiency, and several others. All of these factors should be carefully analyzed and considered, and

Light Sources Spectral Energy Distribution



weighted according to their relation to the ultimate lighting result desired, and to the overall lighting cost.

Light sources used for general lighting purposes, including light for decoration, are of three types: incandescent, fluorescent and mercury vapor. Natural daylight may also be a factor in lighting, especially when window and glass wall areas are involved.

Efficiency—Light source efficiency is measured in lumens per watt. The initial LPW for incandescent lamps range from 17.4 (for 100 watt) to 20 (for 1000 watt); for mercury vapor, LPW range from 38.8 (for 400-watt ASA Desig. H25DE) to 60 (for 1000-watt ASA Desig. H12GW/W); for fluorescent, LPW range from 51 (for 20-watt F20T12) to 70 (for F96T12/HO and F96PG17/CW lamps). These values are for lamp wattages only, and do not include watts loss in ballasts or transformers. Light depreciation throughout lamp life should also be considered, and lamp manufacturers can supply light depreciation curves for the various types of light sources, or average mean lumens per watt, for individual types of lamps.

Light Source Light Output—The total light output of individual lamp types, measured in total initial lumens, should be considered. The higher the light output of individual lamps, the fewer the lamps that will be required to produce a given illumination level. Along with the light output, of course, must be considered the physical size of the lamp, and the size of the luminaire that will be required to house the lamp, (or lamps, in the case of multiple-lamp luminaires).

Spectral Quality—Light is radiant energy which constitutes the visible spectrum. It is composed of pure spectral colors, or so-called color regions. In their simplest form, these color regions are divided into nine well-known parts: violet, blue, blue-green, green, yellow-green, yellow, orange, light red and dark red. These nine colors span the entire visible spectrum, which ranges from about 4000 to 7000 Angstrom units (1 Angstrom equals 10 millimicrons). The color of a colored light source has all (or most) of its energy in the spectral region of that color. Green, for example, ranges from about 4900 A° to 5600 A° (see "Light Sources Spectral Energy Distribution"). When appropriate quantities of radiant energy of these different wave-lengths are combined, so-called "white" light (daylight, for example) results.

Each type of light source produces a different

Fluorescent Lamp Lumen Output Ratios

(Standard Cool White = 100)

Color of lamps	Multiplying Factor
Deluxe Cool White (CW/X)	0.71
Deluxe Warm White (WW/X)	0.71
Daylight (D)	0.93
Soft White (SW)	0.68
Green (G)	1.20
Gold (GO)	0.60
Blue or Pink (B or PK)	0.45
Red (R)	0.06

THE PTL is excellent for estate type subdivisions, driveways, parks, hotel grounds, and recreation areas. The design lends the elegance of low, even lighting and the safety of good light with a minimum of glare. Subdividers and landscape architects will find the PTL well suited to their esthetic needs without sacrificing light efficiency.

New L-M Post Top Light Combines Appearance with High Efficiency

The new L-M PTL (Post Top Luminaire) combines decorative appearance with a highly efficient optical system. It is specially suitable for lighting driveways, residential and institutional grounds, schools, stores, subdivisions, parks, swimming pools, railway platforms, bus stations, and other places where the designer wants both good appearance and efficient light utilization.

Rigidly Built

The PTL combines a rigid spun-aluminum reflector, an efficient Holophane® refractor, and a sturdy aluminum mounting base. Reflector swings open on hinge for easy cleaning, and for replacement of lamps and ballasts.

Reflector and base in natural brushed aluminum, or choice of pastel colors. Available with small cadmium-sulphide photo control, which automatically turns light on at dusk and off at dawn.

Choice of Five IES Patterns

For use with incandescent lamps up to 10,000 lumens, or 620 watts multiple; or with ballast in fixture for mercury vapor lamps up to 250 watts. Choice of five IES light patterns; types I, II, III, II 4-way, and V.

Two styles, for mounting on 3-inch or 7-inch poles. Tapered aluminum poles are available, to provide from 11- to 25-foot mounting heights.

Attractive Low Prices

Prices of the PTL luminaire start at $44; aluminum poles $46 and up. Mail the coupon below for free data sheets and details. Or contact any of the L-M offices listed on the other side.

THE NEW L-M PTL provides elegance of appearance and efficiently controlled light distribution. Available in brushed aluminum, or pastel colors, for 3- or 7-inch poles. For incandescent lamps, or with ballast for mercury vapor lamps. The PTL is also available with small photo control. Prices start at $44.

LINE MATERIAL® Industries

McGRAW-EDISON COMPANY

McGRAW EDISON

See Other Side

Outdoor Lighting

LINE MATERIAL INDUSTRIES,
Milwaukee 1, Wisconsin

☐ Please send me Bulletin 58203 on the PTL

☐ Also bulletins on other types of outdoor lighting

ECM59

385

Name_____

Firm_____

Address_____

City_____ State_____

Please check: ☐ Architect

☐ Builder ☐ Consulting Engineer

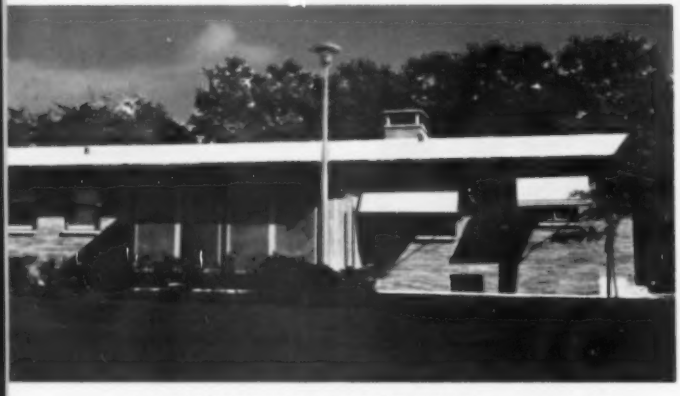
☐ Utility Company

☐ Other_____

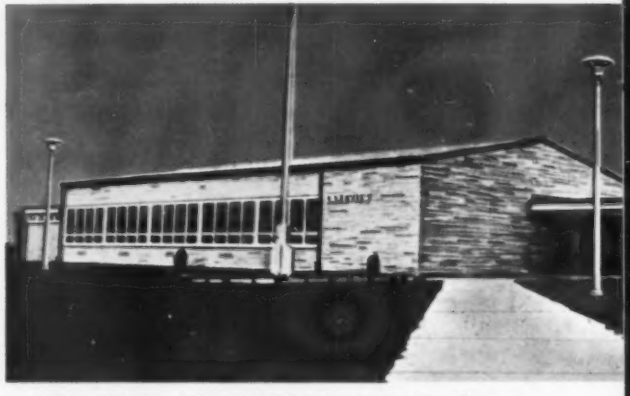
NEW L-M POST TOP LUMINAIRE

THE PTL is excellent for drive-ins, restaurants, hotels, motels, store fronts, shopping centers, water-front areas, railway stations, and many other applications.

Either incandescent or mercury lamps may be used. When the PTL is used for mercury vapor, the ballast is mounted in the fixture where it is easily accessible.



FOR INSTITUTIONAL OR RESIDENTIAL ground lighting, the PTL offers fine appearance, with efficiency. It spreads a soft, uniform light over a large area, with minimum glare.



NEW SCHOOL—NEW LIGHTING! L-M Post Top Luminaires add beauty to the facade, and provide excellent decorative and safety lighting for the area around the building.

. . . AND NOW. Conversion of this old light standard with a new PTL is more in keeping with the modern appearance of the building of the Bank of Naperville, Ill. The PTL will modernize most existing upright standards by direct replacement at a cost comparable to the replacement of two old-fashioned ornamental glass globe and canopy combinations.

For detailed specifications, mail the coupon on other side— or phone or write any of these

SALES OFFICES

Albany 4, N.Y.	966 Broadway
Albuquerque, N.M.	1312 Mesilla, N.E.
Allentown, Pa.	2405 Fairview St.
Anchorage, Alas. (Spenard)	4502 Lois Dr.
Arlington 6, Va.	204 Shirlington Trust Bldg.
Ashland, Ky.	1715 Ashland Ave.
Atlanta 6, Ga.	1261 Chattahoochee Ave., N.W.
Austin, Texas	606 West Ave.
Birmingham, Ala.	1700 Vanderbilt Rd.
Boise, Idaho	614½ State St.
Buffalo 2, N.Y.	843 Delaware Ave.
Butte, Mont.	743 Wyoming St.
Canton, Ohio	814 So. Woodside
Charlotte, N. C.	3205 Monroe Rd.
Cincinnati 43, Ohio	7822 Maplelea f Dr.
Cleveland 14, Ohio	850 Euclid Ave.
Columbia, S.C.	7129 Devine St.
Columbus 15, Ohio	5 E. Long St.
Dallas 2, Texas	1909 Hi-Line Drive
Davenport, Iowa	9 Shady Lane
Denver 2, Colo.	5105 E. 39th Ave.
Des Moines, Iowa	701 Continental Bldg.
Detroit 2, Mich.	611 Stephenson Bldg.
Duluth 4, Minn.	3331 E. Superior St.
East Stroudsburg, Pa.	North Burson St.
Excelsior, Minn.	249A, Vine Hill, Rte. 4
Fort Wayne, Ind.	2904 Inwood Dr.
Glen Burnie, Md.	705 Baltimore & Annapolis Blvd., N.W.
Grand Rapids 5, Mich.	1837 Providence, N.E.
Green Bay, Wis.	1119 Spence St.
Harrisburg, Pa.	2700 Paxton St.
Houston, Texas	5715 Navigation Blvd.
Indianapolis 4, Ind.	155 E. Market St.
Jackson 6, Mich.	1534 Daniel Road
Jackson, Miss.	654 S. Roach St.
Jacksonville, Fla.	1641 Landon Ave.
Knoxville, Tenn.	4206 Terrace View Dr.
Lafayette, La.	1216 Mudd Ave.
Los Angeles 22, Calif.	7105 S. Paramount Blvd.
Madison, Wis.	405 Tompkins Drive
Melrose Park, Ill.	4700 Lake St.
Memphis 7, Tenn.	1169 Morehead St.
Miami 38, Florida	7240 N. E. 4th Ct.
Milwaukee 1, Wis.	700 W. Michigan St.
Minneapolis 20, Minn.	900 W. 79th St.
Moorhead, Minn.	918 So. First St.
Murrysville, Pa.	P.O. Box 297
Nashville 4, Tenn.	1503 Laurel St.
Newington, Conn.	54 Pane Rd.
New Orleans 22, La.	2860 Arts St.
New York 6, N.Y.	74 Trinity Pl.
No. Kansas City, Mo.	10th & Erie Sts.
Oklahoma City 5, Okla.	317 N. E. Hill St.
Omaha 3, Neb.	3415 Cuming St.
Philadelphia 2, Pa.	Broad & S. Penn Sq.
Phoenix, Ariz.	625 W. Madison St.
Pine Bluff, Ark.	1904 W. 31st St.
Portland 9, Ore.	1333 N. W. 12th Ave.
Raleigh, N.C.	216 Russ St.
Revere, Mass.	570 Revere Beach Parkway
Richmond 20, Va.	4111 W. Clay St.
Roanoke, Va.	915 S. Jefferson St.
Sacramento 18, Calif.	1123 Twenighth Way
St. Louis 1, Mo.	706 Chestnut St.
Salt Lake City 10, Utah	980 S. 6th West St.
San Antonio, Texas	1517 Majestic Bldg.
Seattle 99, Wash.	1220 W. Nickerson St.
Sioux City, Iowa	3606 Court St.
So. San Francisco, Calif.	360 Shaw Road
Spokane 24, Wash.	E. 3303 Ferry St.
Springfield, Ill.	Illinois Bldg.
Springfield, Mo.	961 S. Weller
Syracuse 2, N. Y.	221 Erie Blvd. W.
Tampa 2, Florida	306 No. Newport Ave.
Topeka, Kan.	1428 Bella Ave.
Union, N. J.	Inris Industrial Park
Wichita, Kan.	1400 N. Charles
Zanesville, Ohio	Pershing Road

In Canada: Canadian Line Materials, Ltd., Toronto 13, Ontario

Color Temperature of Various Light Sources

(Measured in Degrees Kelvin*)

Light Source	Degrees K*
Natural Daylight	
Light from clear blue sky	12,000–27,000
Light from hazy or smoky sky	7,500–8,400
Light from totally overcast sky	6800
Sunlight, plus light from clear sky (noon)	6500
Direct sunlight (noon in midsummer)	5800
Light from heated sources**	
"Daylight" fluorescent lamps**	6500
Blue (daylight) photoflash lamps	6300
Cool white fluorescent lamps**	4500
Clear photoflash lamps	3800
White (standard) fluorescent lamps**	3500
Photoflood lamps	3400
500-watt projection lamp	3175
1000-watt standard incandescent lamp	3000
500-watt standard incandescent lamp	2950
60-watt standard incandescent lamp	2800

*Absolute temperature scale having its zero at—273°C or—459.4°F.
**By definition, color temperature applies only to light generated by heat (same color as a *black body* at that temperature), but fluorescent lamps have been arbitrarily color-designated in degrees Kelvin for purposes of simplicity.

"color quality" of light. That is, each type produces radiant energy of different wavelengths, which the eye perceives as a color sensation depending on how the radiant energy is distributed over the visible spectrum. This is true of natural daylight, which varies in "color" throughout the day, and of candles, oil lamps, electric light sources, and others. Thus the lighting designer is working with "color," fundamentally, when he works with light; and spectral quality of light sources selected for any specific lighting application should be selected on the basis of its appropriate "color quality" for the lighting results required, or desired.

Light sources which produce so-called "white" light have an inherent "color quality," which is expressed in terms of "color temperature," and measured in degrees Kelvin. A light source is said to have a certain color temperature (see table "Color Temperature of Various Light Sources") when its radiation has the identical color characteristics as a black body at this stated temperature. The Kelvin temperature scale has its zero at −273 degrees C, or at −459.4 degrees F, sometimes referred to as absolute zero. Thus the color quality of a cool white fluorescent lamp, rated at 4500°K, for example, is the same as that of a black body heated to a temperature of 4500 degrees above absolute zero. A black body, it should be further noted, is a theoretical object which is assumed to have perfect characteristics for emitting all the colors of the visible spectrum from red to violet, as its temperature is increased from a point where it barely glows a deep red until it reaches a white heat, and eventually its melting point.

Strictly speaking, color temperature should be applied only to light which is generated by heat, such as daylight, or incandescent filament lamps. However, the general practice of light source manufacturers in distinguishing one "white" fluorescent lamp from another by the use of a Kelvin (color temperature) designation, to differentiate between warm and cool "whites," has become quite well known and generally accepted by lighting engineers, and to a lesser extent by the public. Also, the need for balancing the color quality of light (by filters) to match the light response characteristics of color films in color photography, has made the use of color temperature designations of light familiar to millions of professional and amateur photographers. Thus it is a nomenclature of lighting technology which the lighting engineer should recognize and adopt.

In general, incandescent filament lamps produce a yellowish white light. The lower wattage incandescent lamps produce a light that is distinctively yellow, and the higher wattage lamps (operating with a higher filament temperature) produce a "whiter" yellow.

Mercury vapor lamps produce a blue-green "white" light basically, devoid of yellow-orange-red light. By means of phosphor coatings, however, the light source manufacturers have been able to improve the color quality of these lamps, and improved "whites," including a "yellow" lamp, have resulted. Manufacturers' literature should be referred to for complete details.

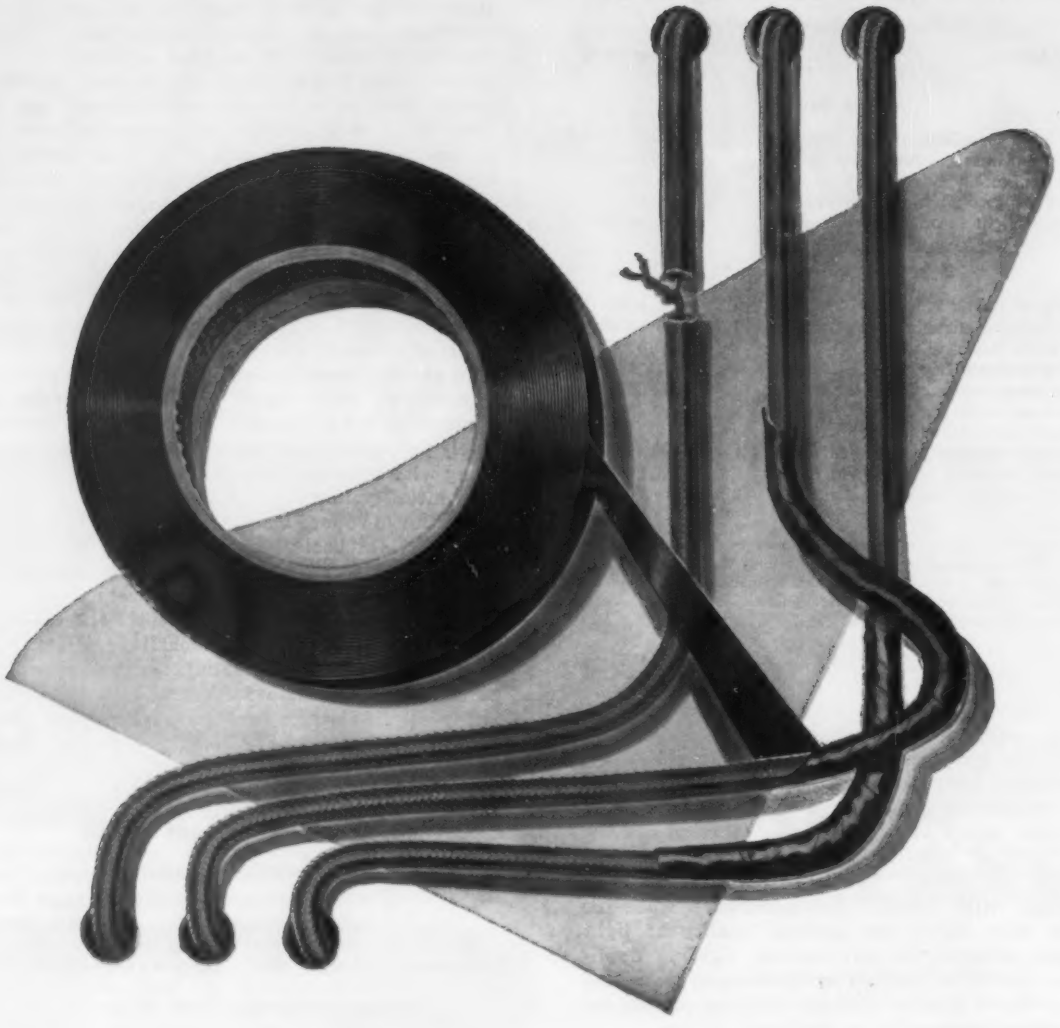
Fluorescent lamps are purposely made in a variety of "white" colors for use in general light-

Standard Fluorescent Lamps

(For General Lighting Purposes)

Lamp Designation	Rated Life[1] (Hours)	Burnouts Per BLH[2]	Light Output[3] Total Lumens	LPW[4]	Brightness Ft.-Lamberts
Preheat Start Lamps (Starters Required)					
F40T12.....	7500	50	2650	67	2000
F90T17.....	7500	26	5150	58	2250
Rapid Start Lamps (No Starters Required)					
F40T12/RS....	7500	50	2650	66	2000
High Output, VHO, SHO, PG Lamps					
F48T12/HO...	7500	41	3250	54	2600
F72T12/HO...	7500	26	5200	61	2650
F96T12/HO...	7500	18	7300	70	2700
F48PG17.....	7500	22	6000	56	3700[5]
F72PG17.....	7500	14	9300	60	3700[5]
F96PG17.....	7500	10	13000	65	3800[6]
F96PG17[6]....	7500	9	15000	70	....
Slimline Lamps (Instant Start)					
F48T12.....	7500	58	2300	61	1850
F72T12.....	7500	37	3600	65	1850
F96T12.....	7500	26	5050	68	1850

[1]Rated life based on burning 3 hours per start. See table "Rated Average Life of Fluorescent Lamps" for burning longer than 3 hours per start.
[2]Burnouts per billion lumen hours, based on 7500-hour life.
[3]Initial lumens after 100 hours of burning.
[4]Lumens per watt are based on lamp wattage only, and do not include watts loss in ballasts.
[5]Average footlambert at 45° angle.
[6]Improved lamp using grooves on both sides of lamps.
Source: Based on data published in General Electric Co. bulletins.



whatever the job . . .

PERMACEL®

PERMACEL *New Brunswick, N. J.* TAPES • ELECTRICAL INSULATING MATERIALS • ADHESIVES

Standard Mercury Vapor Lamps

(For General Lighting Purposes)

ASA Lamp Designation[1]	Approx. Watts[2]	Bulb	Rated Initial Lumens[3]	Lumens Per Watt[3]	Rated Average Life[4]
H4AC/W	100	PS-25	4,000	40.0	6,000
H22KF/W	175	BT-28	7,700	44.0	6,000
H5KC/W	250	BT-28	12,000	48.0	10,000
H25DE	400	BT-24	15,500	38.8	6,000
H1-CD	400	BT-37	21,000	52.5	10,000
H1-GL/W	400	BT-37	23,000	57.5	10,000
H33-1-DN/W	400	R-57	22,500	56.3	10,000
H17GL/C	425	BT-37	20,500	51.3	10,000
H24CD	6.6A	BT-37	20,000	....	10,000
H18ND/W	700	BT-46	40,000	57.1	10,000
H12GW/W	1000	BT-56	60,000	60.0	10,000
H9FJ	3000	T9½	132,000	44.0	6,000

[1]New ASA designations have been adopted by all light source manufacturers.
[2]Lamps only. Does not include transformer watts loss.
[3]Based on average measurements with lamp in vertical burning position at rated watts after 100 hours' operation. Approximate mean lumens also available from manufacturers.
[4]Based on five hours per start. Increase in hours per start also increases average life.
Source: Westinghouse Lamp Division.

ing applications. These include daylight (6500°K), cool white (4500°K), white (3500°K), and warm white. In addition, there are two "deluxe" lamps —the deluxe cool white, and the deluxe warm white—in which phosphors are used to provide more red and orange radiation and thus more closely approximate a continuous-spectrum light.

Light Control—Incandescent lamps, and mercury vapor lamps to a lesser degree, are considered point sources of light. The light output can thereby be quite accurately controlled by means of reflectors or prismatic glass or plastic reflectors or refractors.

Fluorescent lamps are line sources of light, of fairly large diameter; hence, the light output is fundamentally of a diffuse character. Control of the light output from these lamps is less accurate, and generally limited to shielding, or to further diffusion.

The degree of light control needed, from a light distribution standpoint, to achieve a specific lighting result, thus becomes a factor in the selection of the light source.

Heat—All light sources create heat. This heat is a result of the watts of electric energy consumed by the lamps, and each watt produces 3.14 Btu per hour. The more efficient the light source is (lumens output per watt—LPW), the smaller will be the heat load in producing a given level of illumination, assuming the same lighting system efficiency for different types of light sources.

Heat, as a by-product of the lighting system, may or may not be a problem to be considered by the lighting engineer. For air conditioned areas, the heat has to be dissipated through increased capacity of the air conditioning system. On the other hand, this heat may help reduce the heating problem for the area in the cold winter months.

With the low levels of illumination which have been prevalent until the past few years, heat has not been a major problem in lighting. However, if the recently adopted IES recommended levels of illumination are put in practice by lighting engineers, the amount of heat produced will definitely become a factor, and in most cases a problem.

In the case of fluorescent lighting, and especially of the use of high output and super-high output fluorescent lamps, heat is already a problem. This problem is one of dissipating the heat from the ballast to keep it within a range of 90°C to 105°C, which should be done through proper design of the luminaire, and through provision of adequate ventilation, especially in the case of recessed equipment. Also, the efficiency of fluorescent lamps is sensitive to ambient temperature and air drafts. They operate at maximum efficiency in ambient temperatures of 80°F to 95°F, and should be shielded against drafts of cold air.

Lamp Life—Light sources deteriorate from use, thus have a "rated average life" expectancy.

Incandescent lamps of the large lamp type normally used for general lighting purposes have a rated average life of 1,000 hours, except for certain sizes and types which are rated at 2,000 hours for use in special high bay applications to help reduce maintenance costs, and for certain reflector-type lamps used for show window, floodlighting, and other similar applications.

Rated average life of fluorescent and mercury vapor lamps is a function of the frequency of starting the lamps, as well as number of hours operated. Both are characteristically long-life lamps. Fluorescent lamp life is shown in the chart "Rated Average Life of Fluorescent Lamps." Rated average life of mercury vapor lamps now ranges from 6,000 to 10,000 hours, for most types, but manufacturers' literature should be checked for exact ratings and lumen maintenance.

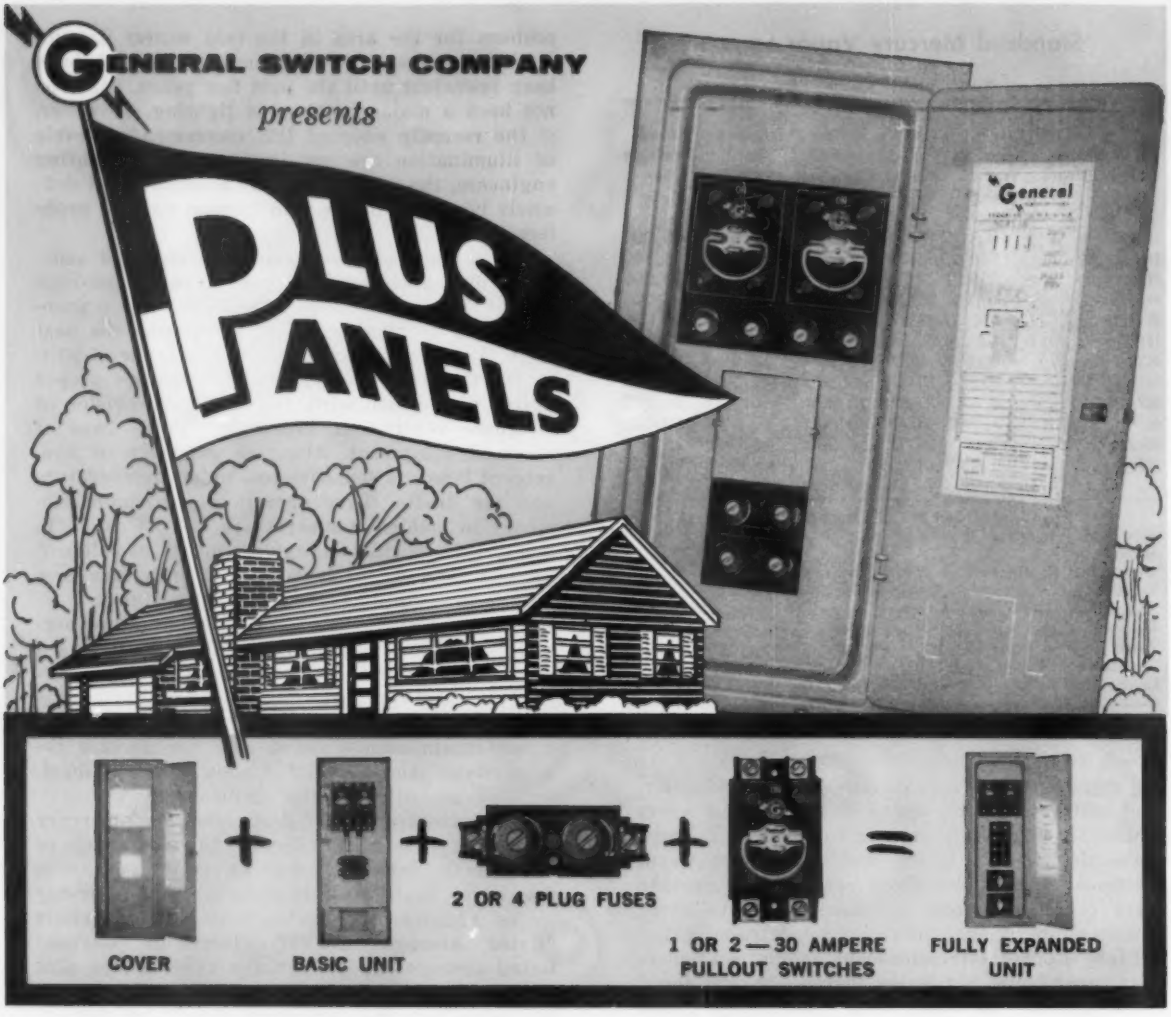
An excellent factor for comparing lamp life of one light source with another, and for making economic analyses, is "burnouts per billion lumen

Standard Incandescent Lamps

(For General Lighting Purposes)

Lamp Designation	Rated Life (Hours)	Burnouts Per BLH**	Light Output Initial Lumens	Light Output Initial LPW
100-w A19	750	...	1,740	17.4
150-w A23	750	...	2,700	18.0
200-w A25	750	381	3,800	19.0
200-w PS30	750	360	3,700	18.5
300-w PS30	750	224	5,950	19.8
300-w PS35	1000	196	5,700	19.0
500-w PS40*	1000	98	11,200	22.4
750-w PS52*	1000	63	17,100	22.8
1000-w PS52*	1000	47	23,400	23.4
1500-w PS52	1000	31	33,000	22.0
500-w R52	2000	73	7,550	15.1
750-w R52	2000	50	12,700	16.7
750-w T24	1000	70	14,200	19.0
1000-w T24	1000	50	20,000	20.0

*Coiled-coil filament axially mounted.
**Average lamp burnouts per billion lumen hours (calculated).



NEW PLUS PANEL CONSTRUCTION PROVIDES EXPANDABLE SERVICE ENTRANCE EQUIPMENT

FOUR BASIC CATALOG NUMBERS, each 100 Amp. main rated, provide adequate service for immediate use and reserve facilities for housepower to be added later.

CAT. NO. 2514: "Main-Range and Four" with reserve housepower to **add** four lighting circuits.

CAT. NO. 2518: "Main-Range and Eight" with reserve housepower to **add** two or four lighting circuits.

CAT. NO. 518: "Main and Eight" with reserve housepower to **add** up to four lighting circuits and also two appliance pullouts.

CAT. NO. 5518: "Main-Range and Eight" with reserve housepower to **add** up to four lighting circuits and also two appliance pullouts.

THE SWITCH IS TO GENERAL

WRITE FOR PRODUCT DATA BULLETIN NO. 135.

GENERAL SWITCH COMPANY
DIVISION OF NORBUTE CORPORATION
45 ROEBLING STREET • BROOKLYN 11, N. Y.

MANUFACTURERS OF ENCLOSED SAFETY SWITCHES • SERVICE ENTRANCE EQUIPMENT • BRANCH CIRCUIT PANELS

hours." This factor may be calculated for any light source by dividing one billion by "average lamp life" in hours times "mean light output" in lumens. This indicates the number of lamps to be purchased and replaced to provide a fixed quantity of light output. Burnouts per billion lumen hours have been shown in the two tables—"Standard Fluorescent Lamps" and "Standard Incandescent Lamps."

Stroboscopic Effect—For most lighting applications, stroboscopic effect, or flicker, is not a problem. However, for certain applications, such as floodlighting a tennis court, or lighting of moving parts in industrial applications, it should be avoided. The stroboscopic effect of filament lamps is too low to be a problem, but may be sufficiently high on electric discharge type lamps to be a problem under certain circumstances. It can usually be minimized enough to be considered practical for use by operating the lamps in a specific area on three separate circuits, each circuit supplied from a separate phase. Another solution is to use high frequency power for the lighting system.

Rated Average Life of Fluorescent Lamps

Type of Lamps	Burning Hours Per Start			
	3	6	12	Continuous*
T-8 and T-12 preheat, rapid start, high output; T-6, T-8 and T-12 slimline; T-12 instant start; T-17 preheat; All circlines	7500	Plus	Plus	Plus
T-17 instant start; 6-, 8-, 13-watt T-5 preheat; 14-watt T-12 preheat	6000	25%	60%	150%
Power Groove lamps	5000			
4-watt T-5	4000			
Cold cathode LP	15000	Life not affected by number of starts		
Cold cathode HP	25000			

*Light output depreciates steadily as lamps are burned. Where infrequent starting, or continuous burning are involved, lamps should be replaced before they reach average life, for maximum lighting value.

Step 5. Select Appropriate System

The luminaires and lighting equipment should further be selected based on their suitability for the area involved, from the standpoint of architectural design and general appearance, structural details, etc. These factors should also be discussed with and agreed upon by the architect, or interior designer, or others charged with the responsibility of the appearance and structural details of the entire project.

Installation—The method of mounting to be used for the lighting equipment will also dictate its selection, and affect the type of lighting system to be used. For example, if an indirect lighting system is indicated, based on the seeing problems involved and on the lighting result desired, this would preclude the use of recessed equipment in a suspended ceiling. Or, if ceiling heights are too low to make practical an indirect lighting system, a compromise in the type of lighting system to be used will be called for. Large-area low-brightness-type luminaires, for example, might be substituted, and be either surface mounted or recessed.

Physical Characteristics—Luminaires selected should be carefully analyzed from the standpoint of mechanical construction, installation features, electrical details, and ease of maintenance. Only equipment of quality construction throughout should be considered. Electrical parts should bear the Underwriters' Laboratories (UL) label, ballasts should be of the high power factor type, and bear the Certified Ballast Manufacturers' (CBM) certification label. Lamps and ballasts should be readily accessible, for ease of maintenance, and installation features should be simple so that a minimum of time is required for installing. Fluorescent luminaires should further be properly designed so that ballasts will operate continuously without exceeding the temperature limit (105°C) for which designed.

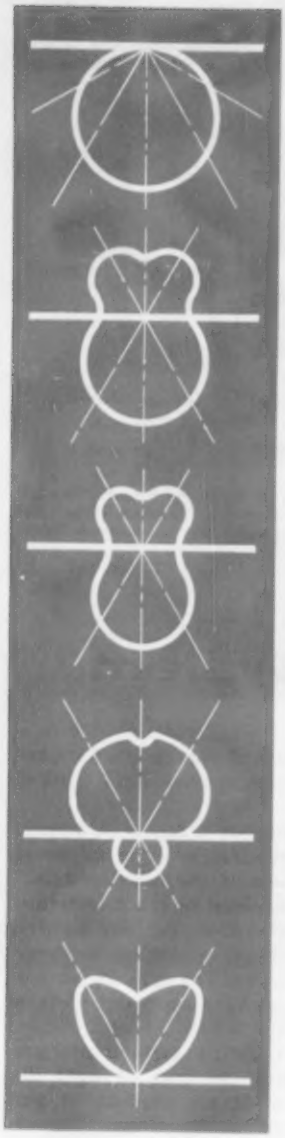
If the building construction is based on a modular dimension, the luminaires or lighting equipment should also be based on the same module.

Several factors are involved in the selection of an appropriate lighting system, for any lighting application, as outlined below; some technical, others artistic or decorative. The type of job will, of course, control the decision on many of these factors.

Light Distribution—Lighting systems are generally classified according to type of light distribution characteristics—direct, semi-direct, general diffuse, semi-indirect, and indirect. End use of the areas to be lighted, and seeing tasks involved, will influence the type of system selected.

Lighting systems consist of luminaires, various types of lighting equipment, light sources, auxiliary devices, and controls. The selection of these luminaires, equipments and devices can best be made based on practical and continuing experience. This is one of the fundamental reasons why a qualified lighting engineer should be retained on a professional basis (lighting consultants, electrical engineers) for the design of every lighting system.

Luminaires and Lighting Equipment—The size of individual luminaires, or lighting equipment devices, is dictated by the type of light sources to be used, and the overall light output required per unit, taking into account its overall efficiency and coefficient of utilization for the area involved. This factor is discussed in more detail under "Lighting Calculations" on the following page.



Types of Lighting Systems

ICI* Light Distribution	Type of Luminaires	Type of Mounting	Lighting System Classification
Direct 90 % to 100% Downward	Recessed	In Ceiling	Recessed (Inc. or Fl.)
	Individual Unit	On Ceiling	Surface Mounted Direct
	Continuous Row		
	Individual Unit	On Ceiling	Suspended Direct
	Continuous Row		
	Luminous Architectural Elements	On Ceiling, Side Walls, or Columns	Architectural
	Decorative Ornamental	On Ceilings or Walls	Ornamental
	Large-Area Low-Brightness	Recessed In Ceiling	Luminous Element
	Diffuser Ceilings	Form Ceiling	Translighted Ceiling
	Louver Ceilings		
Semi-Direct 60% to 90% Downward	Individual Unit	On Ceiling	Surface Mounted Semi-Direct
	Continuous Row		
	Individual Unit		Suspended Semi-Direct
	Continuous Row		
	Luminous Cornice	On Wall near Ceiling	Architectural
General Diffuse 40% to 60% Downward	Individual Unit Continuous Row	On Ceiling	Suspended Direct-Indirect
Semi-Indirect 60% to 90% Upward	Individual Unit	On Ceiling	Suspended Semi-Indirect
	Continuous Row		
	Luminous Cove	On Wall	Semi-Indirect
	Wall Bracket With Downward Component		
	Luminous Ornamental	On Ceiling	Suspended Semi-Indirect
Indirect 90% to 100% Upward	Individual Unit	On Ceiling	Suspended Indirect
	Continuous Row		
	Wall Urns	On Wall	Indirect
	Cove	On Wall or In Ceiling	Cove
	Pedestal	Floor or Counter Top	Indirect
	Ceiling Soffit**	In Ceiling	Indirect**

*International Congress on Illumination approved classification of lighting systems according to a range of distribution of total light output upward or downward, in percentages as shown. A more detailed classification, as given here, has been found through practice to be more practical.
**According to ICI practice, soffit lighting might be classified as "direct". In actual practice, it is normally referred to as "indirect," since it is actually a form of cove lighting.

Step 6. Make a Lighting Calculation

Procedures for making lighting calculations are provided in all lighting handbooks, and in many of the catalogs of lighting equipment manufacturers.

The normal routine is to select a specific type of luminaire, and then select a specific luminaire of this type as made by a specific lighting equipment manufacturer. From the manufacturer's catalog determine the coefficient of utilization and maintenance factor for this specific luminaire. The coefficient of utilization selected should be that CU value listed for the room index of the area to be lighted. Room Index tables are also provided in most manufacturer's catalogs, and in lighting handbooks. Lumen output for the light sources being considered are available in the lamp manufacturers' literature and lamp price schedules.

Use the standard lighting formula, and calculate for total lumens required to produce the footcandle levels of illumination desired. Divide the total lumens required by the total lumen output per luminaire. This gives the number of luminaires required for the total area.

In making these calculations, the values may be related to the total area of the project, to the area per luminaire, or to the area per bay or other convenient or practical subdivision.

Meet Today's Needs for Higher Industrial Lighting Levels with fixtures bearing the

RLM Quality Label

New, Higher I.E.S. Industrial Lighting Recommendations make the RLM LABEL MORE IMPORTANT THAN EVER BEFORE!

Q *Why do the new, higher, lighting levels now recommended by the Illuminating Engineering Society make the* **RLM LABEL** *More Important than ever?*

A *You can't have Quality Lighting without* **QUALITY LIGHTING FIXTURES.**

Higher Lighting levels put more importance on conformance to highest RLM concepts of lighting fixture design, construction, performance and maintenance features.

Q *What is meant by... "Only the RLM Label provides this essential warranty of* **UNIFORM QUALITY..."?**

A *It takes over* **1000 WORDS** *to cover the RLM specifications* for each type of fixture. Further, it requires the services of the Electrical Testing Laboratories of New York (an independent engineering organization) to insure uniform and consistent conformance by making periodic tests from samples secured both from the production lines and the field stocks of every participating manufacturer. The simple passing of the tests by the submission of a sample or samples is not enough. To be entitled to the RLM Label, fixtures are subject to continuous examination and must uniformly meet the RLM quality Spec's so as to insure unvarying quality from fixture to fixture.

R-535

RLM STANDARDS INSTITUTE, INC.
Suite 8195, 326 W. Madison St.
Chicago 6, Illinois

THIS COUPON IS FOR MEN WHO WANT *ALL THE FACTS*

☐ Please send the FREE RLM Specifications Book containing latest Specifications and 10 pages of facts about the RLM Label. Also, a complimentary copy of the New Higher I.E.S. Industrial Lighting Recommendations.

Name..... Title.....

Company.....

Address.....

City..... Zone..... State.....

RLM STANDARDS INSTITUTE

Steady plant production demands dependable power cable . . .

HABIRITE-HABIRPRENE CABLE gives unexcelled performance!

To help assure uninterrupted production, modern industrial plants require reliable cables for delivering electric power to production lines. The service reliability of Phelps Dodge *Habirite-Habirprene* is unsurpassed by any other rubber insulated neoprene jacketed type RR cable.

Habirite-Habirprene is a combination of specially engineered butyl rubber insulation and neoprene jacket. The overall features of this cable provide greater resistance to heat, oxidation and ozone; improved electrical properties, including superior insulation resistance; higher copper operating temperature; superior flexibility; improved mechanical toughness against damage from installation hazards and extra resistance to corona, an absolute necessity for high-voltage neoprene jacketed cable.

As a general purpose cable, *Habirite-Habirprene* assures the utmost in safety, durability and reliability.

See Your Phelps Dodge Distributor!

PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Dayton, Denver, Detroit, Fort Wayne, Greensboro, N.C., Houston, Indianapolis, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N.Y., San Francisco, St. Louis, Seattle, Washington, D.C.

If more than one type of light source is being considered, for purposes of comparison, similar calculations should be made for each, and based on the appropriate luminaires for each.

The above comments apply for interior lighting, and for typical luminaires. If indirect lighting is involved, from coves, wall urns, pedestals, etc., the manufacturers' instructions should be followed. Also, for outdoor floodlighting problems, or street or highway lighting, etc., use the IES Lighting Handbook, or manufacturers' instructions, for making the calculations.

Step 7. Prepare a Lighting Layout

When the number of luminaires required has been determined, the next step is to fit these luminaires into the area in a logical and practical arrangement. Symmetrical arrangements, from an appearance standpoint, are usually preferred. Where a special arrangement provides a functional use, such arrangement is usually satisfactory but should be adopted with caution and due regard for appearance.

If the number of units calculated to be correct for the illumination level required does not conform to a symmetrical layout, the number of units should be increased to provide the desired symmetry and best appearance. When such increase in units greatly increases the resulting illumination level desired, it may be possible to reduce the number or size of lamps per unit to achieve the proper lighting level. This may involve another series of lighting calculations and further "trial and error" layouts until the appropriate number of units and layout arrangement has been achieved.

A recent valid criticism of current lighting system design practice is the uniformity of appearance of lighting systems from one installation to another. Such monotony, inherent in continuous row and geometric arrangements of fluorescent lighting equipments, whether surface mounted or recessed, and in wall-to-wall luminous ceilings, is recognized. It is a by-product of mass production of almost identical designs of luminaires and equipments by a large number of manufacturers. The solution to this problem rests with equipment manufacturers and their representatives, and in collaboration with architects and engineers in the design of new and imaginative lighting application techniques. The technological know-how, light sources, and myriad lighting components, for producing the required lighting levels and comfortable visual environments, already exist.

Step 8. Provide for Flexible Control

Electric lighting is now an essential commodity in our way of life. It is in use 24 hours a day, every day, throughout the nation. It is used to light our homes, our places of work, our recreation areas, our streets and highways, tunnels, bridges, outdoor signs, monuments, airports, gasoline service stations, restaurants, theatres, night clubs, etc.

The need for higher lighting levels generally has been recognized. Footcandle levels will be approximately doubled over the next few years from existing levels, especially in retail stores, offices, drafting rooms, and industrial plants.

In view of the increasing levels of illumination, and of the expanding use of electric lighting, the need for greater flexibility in lighting control becomes evident. This need is perhaps greatest for home lighting systems, where it is desirable to create a variety of lighting effects, ranging from low level decorative and mood lighting to high level illumination for reading, sewing, playing cards, and similar activities. Such lighting flexibility also becomes desirable for multi-purpose auditoriums, gymnasiums, school classrooms, and for restaurants, exhibit halls, hotel lobbies, banquet halls, private offices, and many others.

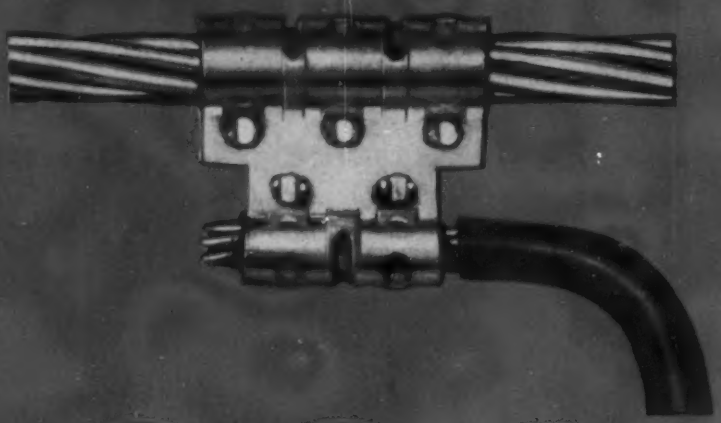
Lighting flexibility can be obtained by either of two basic methods. One method is to use multiple switch control to a single multiple-lamp luminaire, or to a multiple-lamp area such as a luminous ceiling. The other method is to use a dimmer system on all of the lighting circuits. With new and improved dimming devices becoming available, the dimming method is automatically becoming more practicable for lighting systems wherever multiple lighting effects may be desired. Included in the new dimming devices are new and improved methods for dimming fluorescent lighting systems over a broader range of intensities.

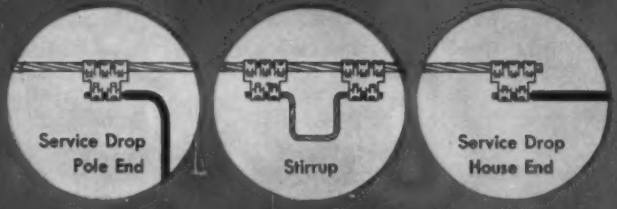
Step 9. Analyze Available Power

Part and parcel of lighting system design is the wiring system which provides the electric power to operate it. In general, this includes the branch circuit wiring, switching, dimmer control, etc. back to the lighting panels, which serve as a practical point of divisional responsibility. Actual design of the branch circuit wiring system may be done either by the lighting engineer, or by the electrical system design engineer in full cooperation with, and under the direction of, the lighting engineer.

In the interest of lighting economics, however, the lighting engineer should go still further. In cooperation with the electrical engineer, he should investigate and analyze the type of electric power which is available for serving the lighting load, especially on lighting projects involving loads of 50

The TAP that TOPS them all...





THE MULTI-PURPOSE AMP UTILI-TAP for aluminum and/or copper conductors

Tired of all the expensive clutter in your stock rooms—a special tool for this, a special piece of hardware for that? Now you can clear out a lot of your inventory clutter with all new A-MP UTILI-TAP.

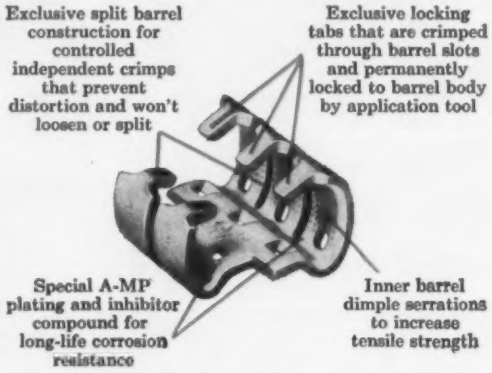
Here is a product that can be used on diverse tapping installations—like no other product on the market. It's permanent, it's sure and it will do many, many jobs.

Your stock can be simplified and easily maintained. Your linesmen can now go up the pole without pockets filled with miscellaneous parts or belts loaded with special tools. Simplify with the A-MP UTILI-TAP.

Light-weight matched tooling available in mechanical or hydraulic types.

The only tap on the market that converts from an easily attached open barrel construction to a permanent, closed barrel attachment.

Look at these unbeatable features:


Exclusive split barrel construction for controlled independent crimps that prevent distortion and won't loosen or split
Exclusive locking tabs that are crimped through barrel slots and permanently locked to barrel body by application tool
Special A-MP plating and inhibitor compound for long-life corrosion resistance
Inner barrel dimple serrations to increase tensile strength

Full range of wire size combinations for aluminum, copper or ACSR conductors.

Send today for more information to solve your tap inventory and reliability problems simultaneously.

American Pamcor, Inc.

API AMERICAN PAMCOR INC.

GENERAL OFFICES: 181 HILLCREST AVE., HAVERTOWN, PA.

Exclusive Distributor For AMP Products To The Utility Industry

Lighting System Voltages

(Single Phase—Volts)

60 Cycle		High Frequency
Incandescent Filament Lamps	Electric Discharge Lamps	Fluorescent Lamps
28–32	110–125	400**
110–125	200–216	600**
220–240	220–240	
	240–280	
	440–480*	

*Mercury lamp transformers.
**Phase-to-phase voltage, with grounded neutral to provide less than 300 volts to ground (NEC).

kw and above, or on many special lighting applications such as athletic field houses, large gymnasiums, armories, banks, air conditioned concentrated-work production areas, etc.

This analysis should include a study of the various voltage and phase combinations available from the electric utility service normally in use, and in the case of exceptionally large lighting loads, of any other electric power service which might be made available on a special basis. Voltages which are now in common usage for lighting systems are given in the table "Lighting System Voltages," for standard 60 cycle power and for high frequency power systems. Once the lighting engineer has completed his basic lighting layout (Step 7), he is in a position of being able to make economic studies to determine the most economical electrical distribution system for the specific electrical loads and length of runs for sub-feeders and branch circuits involved.

Most economic studies over the past few years have shown substantial savings for systems utilizing higher voltages (especially 277-volt lighting systems served by a 480/277-volt 3-phase 4-wire service). Also, many recent studies have shown that higher-frequency power for lighting (360, 400, 840, 1500 cycle systems) offer economic and other advantages.

As higher lighting levels are adopted, the importance of higher voltage distribution systems, and especially of higher frequency electric power at 400 volts or 600 volts, increases. The use of high frequency power has the distinct advantage of reducing the heat load for air conditioned areas of up to 20%, and savings are further reflected in total capacity requirements for air conditioning equipment.

Step 10. Check for Practicality

After completing a lighting system design, it is always a good idea to study it objectively before proceeding with its recommendation or specification. Such study should be made to provide a measure of its economy and practicality.

One of the first things to do, as a precautionary measure, is to double-check all calculations. In making this check, all dimensions should also be verified. Further, the conclusions reached for each of the above nine steps should again be gone over briefly and verified, based on the final proposed lighting system design.

Every lighting system affects other mechanical, electrical, or structural details. Thus the proposed system should be further analyzed to determine that it is practical from these standpoints. Some of the checks which should be made include:

Electrical load—Calculate the total electrical load required for the lighting system, including the watts loss in ballasts, or auxiliaries. Translate this into "watts per sq ft", and compare it with standard, or normal, practice.

Air conditioning—Determine the impact of the electrical load for lighting on the air conditioning system. This factor will normally be handled by the air conditioning engineer, but if the electrical load is considerably higher than normal, it will mean that air conditioning capacity must be installed to take care of it. Such additional capacity should logically be charged against the lighting system in making economic studies. In view of the higher lighting levels being recommended by the Illuminating Engineering Society, as adopted in 1958, this factor will grow in importance as the new lighting levels are adopted and put into use.

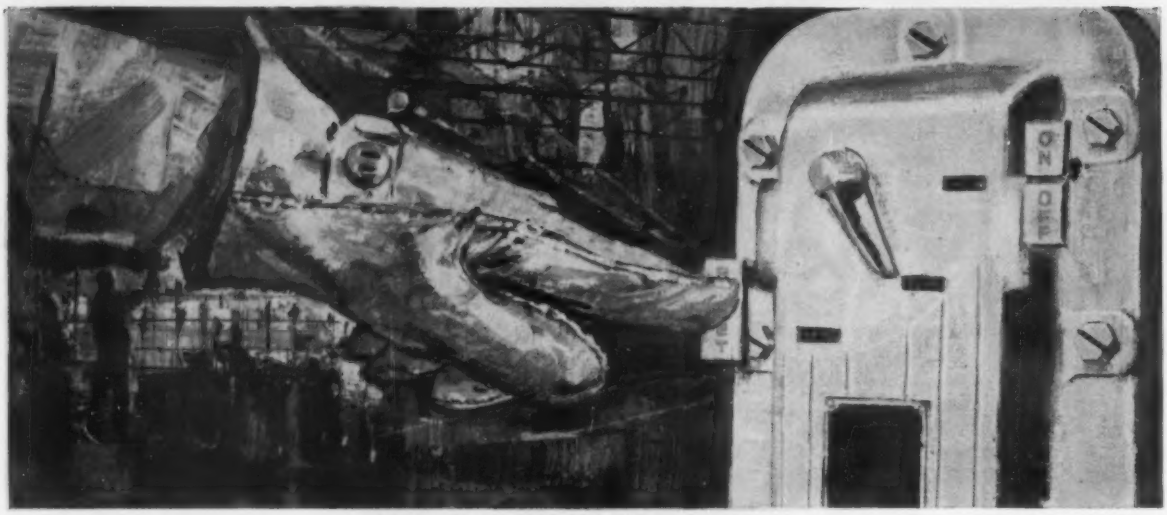
Another factor of importance in connection with air conditioning systems is to check for interference between air diffusers, air ducts, etc., and luminaires or lighting equipment. The lighting engineer must, of necessity, work closely with the air conditioning engineer to resolve such problems of equipment mounting locations.

Heat Dissipation—Since many of the modern lighting systems are of the recessed, or built-in types, it may be found practical and advisable to consider methods for dissipating heat loads from lighting equipment by means of special ventilating systems for the lighting units, so that the lighting system heat load does not become a part of the air conditioning problem. Many studies are already being made on this problem, and this approach should be considered for lighting systems which generate excessive amounts of heat.

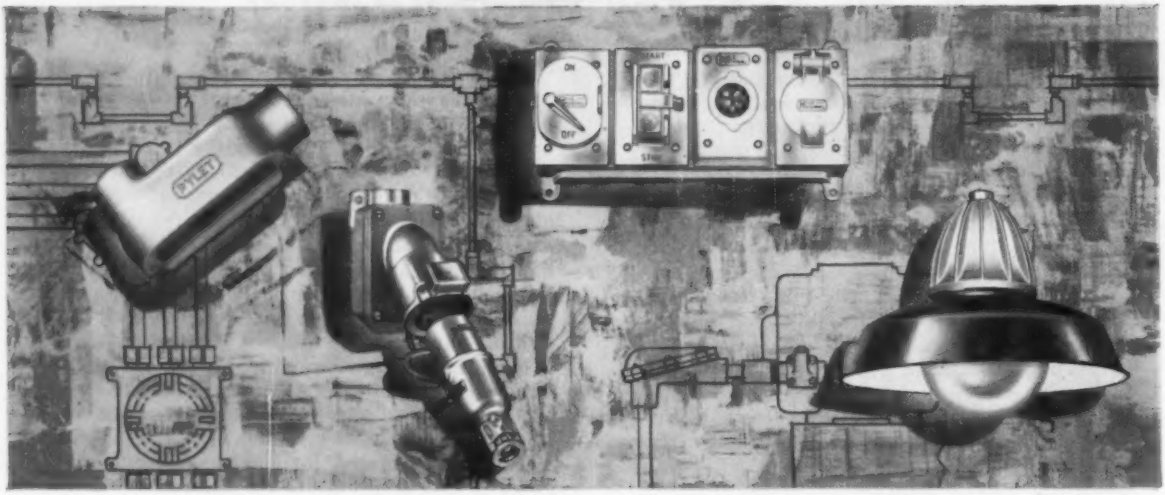
Conflict With Other Devices — The proposed lighting system should be checked for interference with any structural details, or with sprinkler systems, public address systems, etc. Preliminary analysis of the proposed lighting system will at least reveal possible conflicts between the lighting system and these other factors, and aid the lighting engineer in resolving them with the architect or allied trades engineers.

From the owner's viewpoint, both first cost and annual operating cost will be of interest. The lighting engineer should develop estimates for each, on as accurate a basis as possible, and be prepared to discuss these costs in detail. The new third edition of the *IES Lighting Handbook* contains a suggested procedure for such estimates, on page A-28 of the Appendix.

For protection of wiring and equipment



you can rely on PYLETS®



PYLET conduit fittings, circuit controls, lighting fixtures and connectors are second to none for quality and dependable service.

Built-in, environment-resistant features exceed code requirements, to meet the exacting demands of industry today—for both hazardous and non-hazardous locations. Cast metal fittings with taper tapped hubs, smooth roomy interiors and cadmium plating insure economical installation and maintenance as well as long service life.

Specify PYLETS. Sold Nationally through Authorized Distributors.

SINCE 1897

THE PYLE-NATIONAL COMPANY
WHERE QUALITY IS TRADITIONAL

1344 North Kostner Avenue, Chicago 51, Illinois

Connectors • Conduit Fittings • Circuit Controls • Lighting Fixtures • Floodlights

Branch Offices and Agents in Principal Cities of the U.S. and Canada
Railroad Export Department: International Railway Supply Co., 30 Church St., New York 7, N.Y.
Industrial Export Department: Rocke International Corp., 13 E. 40th St., New York 16, N.Y.
Canadian Agent: The Holden Co., Ltd., Montreal

DIVISIONS: Multi-Vent, Air Distribution • Steber Manufacturing Company, Lighting

Supplementary Lighting

Applied lighting practice over the past 20 years or more (especially since the introduction of the fluorescent lamp in 1938) has been to provide general lighting, of more or less uniform footcandle levels, in stores, offices, classrooms, production areas, etc. Illumination levels installed have ranged from about 20 footcandles up to 50 and 75 footcandles for these purposes, with many installations over the past four or five years ranging to 100 footcandles and above, depending on the degree of severity of the seeing tasks involved, and the general acceptance of users of the need for more light.

This practice of installing uniform lighting levels throughout an area replaced the earlier concept, generally in practice in the 1920s and 1930s, of installing low levels of general lighting in an area, and supplementing this low level general lighting with considerably higher lighting levels at the point of work. This so-called "general plus local lighting" approach has been considered more or less obsolete in recent years, except for critical seeing tasks where lighting levels of 200 footcandles and above were used. These tasks involved many applications, however, such as for inspection, fine machining, color work, etc. in industry, and for display lighting in stores, show windows, special exhibits and similar applications. It was found to be desirable and more economical to provide these higher lighting levels for use over small work areas and on displays with supplementary type lighting, superimposed on average level general lighting of sufficient quantity to maintain acceptable brightness ratios in the general field of view of the workers, or viewers of displays.

Supplementary lighting has usually been accomplished with reflector-type units installed close to the work areas, or with reflector spot or flood lamps in suitable fixed or adjustable type holders. Both incandescent and fluorescent units have been used for this purpose.

The point-by-point method of calculation is used to determine estimated footcandle values from individual supplementary lighting units. It is necessary, of course, to have a candlepower distribution curve for the unit being considered. Footcandle values may then be calculated for a point at any angle from the center axis of the unit, or on the axis. Most manufacturers of such equipment also supply charts showing footcandle values over a specified area located a specific distance from the unit, which eliminates the need for time-consuming calculations.

In view of the higher lighting levels now being recommended by the Illuminating Engineering Society for all difficult seeing tasks, it may once again become necessary to adopt the supplementary lighting technique to achieve these new higher lighting levels economically. Lighting engineers may well find it advisable to consider this approach to many of their high lighting level projects, and to study new and better techniques for providing supplementary lighting.

Color in Lighting

Color is a most important consideration in lighting design. Yet, it is usually one of the most neglected factors.

All light has color, including daylight. There is no such thing as colorless light. Also, all objects, surfaces, and materials on which light falls (except black) have color. Therefore the lighting engineer, or others who plan a lighting system, is dealing with color. Thus to know and to fully understand color in all its phases is of utmost importance in planning a visually and psychologically pleasant visual environment, for any and every type of interior or occupancy.

The lighting engineer must consider color in lighting from two standpoints. First, he must consider the color of the light being used, or as produced by the light sources. This applies to daylight, and to so-called "white" electric light, as well as to colored light (see *"Spectral Quality,"* under "Step 4. Select Proper Light Source" above). Colored light may be produced directly by the light sources, as is done by all colored fluorescent lamps in which the phosphors produce colored light, or by the subtractive (filter) method, as is done by incandescent lamps using colored glass bulbs, or in reflectors with an accessory color filter.

Secondly, the lighting engineer must consider the color of the objects being lighted, including walls, floors, machines, people, merchandise, etc. Every object on which light falls also has color. By definition, the color of any object is "the capacity of the object to modify the color of the light incident upon it." There is therefore an interdependence of light and color which cannot be ignored, if an acceptably pleasant visual enviromnent is to be achieved.

The lighting designer (or the architect, interior designer, or others) must know the color and reflectance values of the various surfaces in the interior which he plans to light in order to select an appropriate "color" of light source, either of the so-called "white" light, or of colored light, such as red, blue, green, yellow, etc., or conversely he must select appropriate colors for all interior surfaces (ceiling, side walls, floor, furnishings, etc.) which will blend harmoniously with the "color" of the light sources to be used.

Color also creates an effect of psychological significance. It can be used effectively to provide a psychological "warmth," or "coolness," or mood of "action," or of "somberness," etc. So here, too, the lighting designer can provide suitable lighting to complement the decorator's color treatments and thereby produce a more effective decorative "mood," or theme.

Colored light may also be used as such to create unusual and dramatic decorative effects. The pri-

B-M THE ORIGINAL INDENTER FITTINGS

Over 25 Years of Proven Performance

Permanent locked-in bushing insures smooth burr-free raceway for easy fishing. No extra work.

BRIEGEL RED THROAT

1. Protruding rounded red plastic lip of bushing prevents cutting of insulation—eliminates shorts.
2. Full thread screws into all conduit fittings. Lip of RED THROAT bushing protects thread from damage.
3. Deep dished eight pronged lock nut is easier to drive on—screws flush to shoulder and digs into metal of box for vibration proof positive ground.
4. Two quick squeezes with The Briegel Indenter and BM All Steel Indenter Fittings are set forever. Metal is pressed into metal for permanent installation and positive ground.

NEW POCKET SIZE INDENTERS

Just 10" long, these new patented compound leverage indenters are only plier size. Lighter to carry and easier to use—the leverage does the work. No. 607 for ½" and No. 608 for ¾" fittings.

BRIEGEL METHOD TOOL COMPANY

GALVA, ILLINOIS

All B-M Indenter Fittings are U.L. Approved as concrete-tight and for general use (File Card E10863). Also comply With Federal Specifications W-F-406.

ALL BRIEGEL FITTINGS ARE U.L. APPROVED AS CONCRETE-TIGHT

mary colors of light are red, green and blue. By mixing these primary colors of light in proper proportions, white light is produced. By using various combinations and intensities, an almost unlimited range of "color" effects are possible. Applications for this type of lighting are practically endless, and designers should know and understand this subject well to design better and more elaborate systems which reflect true color harmony, and which provide desired dramatic color lighting effects.

Residential Lighting

Lighting for the home should tie in with family life and activities. Family size, living habits, social activities, sports, hobbies, and similar factors vary greatly. Therefore, wherever practical, home lighting should be custom-designed to meet the specific requirements and individual preferences of the individual family.

Fundamental to home lighting design is the provision for a wide variety of lighting effects, to enable the proper environment to be created for each family activity, seeing problem, or decorative treatment. This demands the use of many different lighting techniques and types of lighting devices, with maximum control flexibility. Only through this approach to the home lighting problem can the family begin to approach the many benefits and conveniences of better light for better living.

The principal purpose for lighting in the home is to provide comfortable seeing for work, play and relaxation. But it can, and should, be made to serve many other needs. It should enhance the appearance, the atmosphere and the decorative treatment that helps to transform a house into a home. It should create a sunny and cheerful mood and environment. It should be flexible to permit a wide variation in lighting effects to meet varying moods, and for psychological and decorative value.

The lighting environment in the home, as in commercial establishments, extends beyond and is influenced by more than just the lighting system. It includes the walls, ceilings, floors and furnishings. These areas reflect light and cause rooms to appear larger, more cheerful, more colorful, more livable, when medium to light finishes are used. Dark finishes have the opposite effect.

The broad range of light sources, lighting techniques and lighting units makes it possible to select lighting systems which fit family budgets, yet remain appropriate for varying decorative treatments for individual family habits and requirements. When combined with appropriately finished light colors on all interior surfaces, a more satisfactory lighting environment may be expected.

From a lighting design standpoint, the rooms of a house can be divided into two basic groups. For one group, consisting of living room, dining room, bedrooms, den or study, halls and stairway, and recreation or play room, general diffuse illumination should be provided throughout each room, supplemented by local lighting at all furniture groupings or local areas where higher intensities may be needed for difficult seeing problems. Also, provision should be made to use light in these rooms as a decorative medium. For the other group of rooms, consisting of kitchen, bath, laundry, pantry, etc., or service areas, a higher level of general lighting for utilitarian purposes should be planned.

For general illumination, overhead ceiling lights are generally most satisfactory. In the living room, dining room and bedrooms, these should be decorative in character to harmonize with the furnishings, or may consist of coves, valances and cornices where the budget will permit. Recessed spots and floods carefully shielded, may also be used to light murals, pictures, indoor plants or flower arrangements, etc. Lighted ornaments, wall cabinets, etc. may be used as purely decorative devices.

In the kitchen, uniform general illumination may be provided by a ceiling lighting system, ranging from a single ceiling unit to a complete wall-to-wall luminous ceiling. Large-area low-brightness recessed panels are an excellent intermediary solution. Supplementary lighting should also be provided over all work areas—food preparation, range, dishwashing center. Recessed incandescent units with concentrated light distribution can be used for some of these areas, and fluorescent wall brackets, or fluorescent strip lighting under cabinets, are also suitable where they can be installed.

In the bathroom both an overhead ceiling luminaire and two wall brackets, one on either side of the mirror, are desirable.

Overhead utilitarian lighting units are desirable in the laundry, in the furnace room, over a work bench, in the garage, and in other similar service areas.

IES Recommended Illumination for Residences

	Foot-candles*
General Lighting	
Entrances, hallways, stairways, stair landings	10**
Living room, dining room, bedroom, family room, sun room, library, game or recreation room	10**
Kitchen, laundry, bathroom	30
Specific Visual Tasks	
Table games	30
Kitchen sink	70
Kitchen range and work surfaces	50
Laundry, trays, ironing board, ironer	50
Reading and writing, including studying	
Books, magazines, newspapers	30
Handwriting, reproduction and poor copies	70
Desks, study	70
Reading music scores	
Simple scores	30
Advanced scores	70
Sewing	
Dark fabrics (fine detail, low contrast)	200
Prolonged periods (light to medium fabrics)	100
Occasional periods (coarse thread, large stitches, high contrast thread to fabric)	30
Shaving, makeup, grooming; on the face at mirror locations	50

*Minimum on the visual task.
**General lighting for these areas need not be uniform.

The general principles of good lighting design should be followed in lighting each area of the home. Less emphasis is required on footcandle intensities, except for sewing and study areas, and for locations for relaxed reading, and greater emphasis is desirable on the decorative aspects.

Portable floor and table lamps incorporating good lighting design principles may, of course, be used. But these present the hazard of portable cords, and take up needed floor space. In general, equal or improved lighting effects can be provided by suitable built-in or permanently-installed standard lighting units. When these fixed units are properly controlled by switches or dimmers, full flexibility results and the system is much more satisfactory.

There is such a wide variety of units and equipments available as to make it impracticable to attempt a more detailed procedure for designing the lighting for a home in the limited space available here. It is believed that the general principles of home lighting design outlined above, if followed, will serve as a suitable guide, when implemented by the experiences and inherent creative ability of the average lighting designer.

New recommended levels for home lighting were approved and adopted by the Illuminating Engineering Society in 1958. These new footcandle values are given in the table "IES Recommended Illumination For Residences", and should be followed as a guide for minimum requirements.

Exterior Lighting

Every home needs a certain amount of outdoor lighting for utilitarian purposes. In addition, many homes present an opportunity for the lighting of yards, lawns and grounds for increased use and beauty, and for artistic effects after sundown.

Lighting for utility includes the installation of lighting units at strategic locations for the quick and easy seeing of both visitors and members of the family on entering or leaving the house, garage, or grounds, and to discourage trespassing. This includes an illuminated house number (at driveway entrance, on the lawn, or at the front door), wall brackets, step lights, eaves-recessed or surface mounted floodlights at the front entrance, post-top lanterns at the end of the entrance walk and at the driveway entrance, bracket light or floodlights for the rear entrance to the house and over the garage door, and floodlights or low-mounted lights to light walks and driveways.

Outdoor lighting may also be used for lighting entertainment and play areas, such as tennis courts, outdoor volley and basketball courts, barbecue pits, shuffleboard courts, ping pong tables, croquet courts and private swimming pools. The extent to which this type of outdoor home lighting is practical will be governed, of course, by the existing facilities of this type and the habits and outdoor activities of the family.

Lighting units installed for utility, or to provide safety for entry and exits to the house and garage, may also be used on a special lighting circuit to provide lighting for protection. Also, special floodlights or prismatic lens units may be mounted around the perimeter of the house, and connected to a special circuit specifically for protective lighting.

With more and more families being attracted to outdoor living during summer months, and year-round where climate permits, outdoor lighting for decoration can be used to excellent advantage. Vistas out the living room windows, or from the terrace, can be made most pleasing at night through the intelligent use of light and color. Artistic patterns of light and shadow can be created, and by means of multiple switching arrangements and dimmer control, the total lighting pattern may be adjusted to changing mood and artistic fancy to meet prevailing requirements.

A wide variety of types of outdoor lighting units are now available for lighting flower beds, or shrubbery, for underwater lighting in color of swimming pools or reflection pools, for fountains, lily ponds, rock gardens, and similar points of interest. Brightness patterns may be created outside large glass windows to provide a natural transition between outdoor and indoor areas. Overhead strings of lights, enclosed in Japanese lanterns or similar decorative devices can be used to add gaiety and a festive mood for outdoor parties. Lighting designers can devise individual and artistic applications to suit specific outdoor areas of individual home owners.

Outdoor Lighting

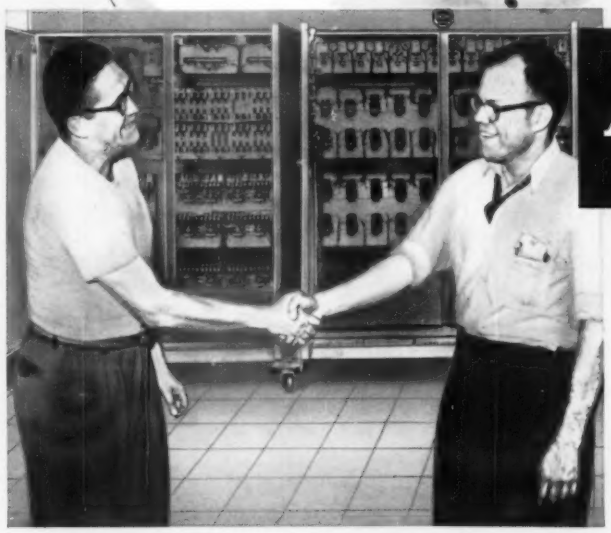
Application trends in outdoor lighting systems are being influenced greatly by the trends in light source design and development. The incandescent lamp has been popular for most outdoor lighting purposes through the years, especially up to the end of World War II. A major reason for this popularity was the fact that the filament lamp provides a point source of light, which makes it easy to control the light distribution from the luminaires; also that first cost of the equipment was generally low.

Over the past 14 years, or since the end of World War II, there has been a growing trend to the use of fluorescent and mercury vapor floodlights and luminaires in practically all phases of outdoor lighting. An inherent advantage in each of these light sources is the long life which may be expected. Long life lamps simplify maintenance and result in lower maintenance costs. Both light sources are inherently more efficient, and produce up to three times as much light for the same power consumption.

In general, mercury vapor lamps are to be preferred where accurate light control or specific light distribution patterns is a major consideration, while fluorescent lamps are ideal for applications which require diffused light. Mercury vapor lamps are, for practical purposes, approximately "point" sources, while fluorescent lamps are "line" sources. However, floodlights and luminaires have been developed for each light source to provide a variety of light distribution patterns, and either light source may now be used for most outdoor lighting applications.

Outdoor lighting system design is specialized, to

Precision Guidance of Nearly a Mile of Plate Glass...



A series of control panels such as this is used in the Pittsburgh Plate Glass cutting room. Above are shown the Allen-Bradley engineers after completing the factory testing of the final panel.

controls by ALLEN-BRADLEY of course!

The New Pittsburgh Plate Glass Plant at Cumberland, Maryland, heralds a new era in the art of plate glass making. Night and day, a continuous ribbon of glass is fed to a nearly mile-long process line. Then a complex control system directs the automatic cutting, sorting, and conveying of the glass to six areas, according to a continuously varying program.

Special control panels which integrate portions of this equipment into a unified, smoothly operating system were designed, developed, and engineered by Allen-Bradley. You can benefit by this extensive control experience . . . it is a "plus" value when you specify Allen-Bradley *quality* motor control.

Allen-Bradley Co., 1316 S. Second St.
Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

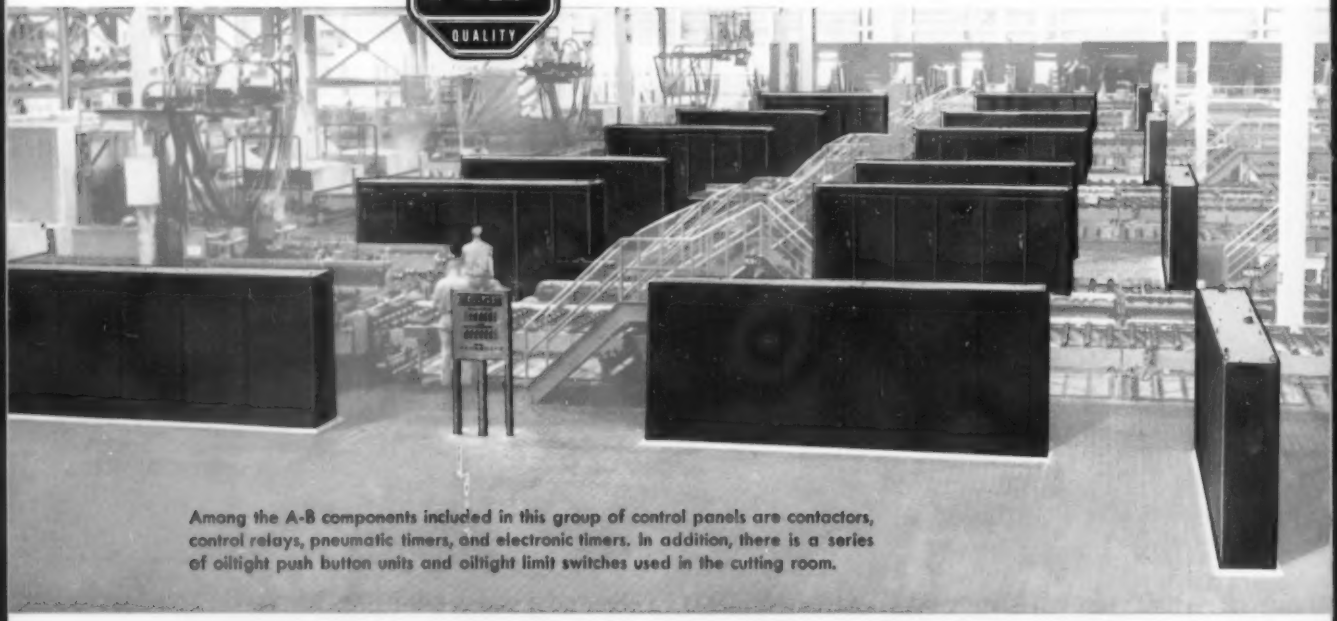
See on the next page how A-B Controls do it... →

5-59-MR

Plate Glass made by the mile

with reliable ALLEN-BRADLEY Controls

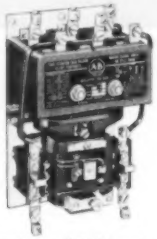
In the cutting room at Pittsburgh Plate Glass (below), Allen-Bradley controls prove the reliability of their "simple design." All A-B solenoid starters, contactors, and relays have only ONE moving part . . . assuring *millions* of trouble free operations. There are *no* bearings or jumpers to cause trouble. Contact maintenance is also eliminated — A-B double break, silver alloy contacts remain in perfect operating condition until completely worn away. Insist on Allen-Bradley *quality* motor controls . . . you cannot do better!



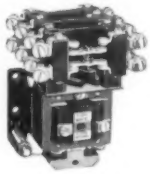
Among the A-B components included in this group of control panels are contactors, control relays, pneumatic timers, and electronic timers. In addition, there is a series of oiltight push button units and oiltight limit switches used in the cutting room.

Some of the standard components which are used in this plant

Contactor—Bulletin 702, Size 3 shown. Made up to Size 8, rated 1350 amps, 220-550 v.

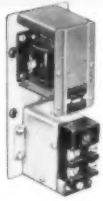


Solenoid Starter Bulletin 709, Size 2 shown. Made in ratings to 450 hp, 220v; 900 hp, 440-550 v.



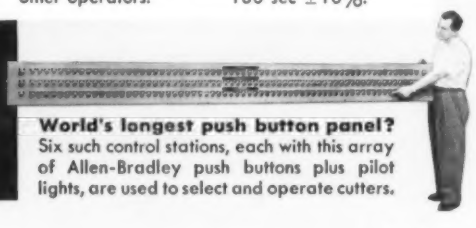
Control Relay—Bulletin 700. Universal type relay with both N.O. and N.C. contacts shown.

Limit Switch—Bulletin 802T. Oiltight roller lever type shown. Also with many other operators.



Pneumatic Timer Bulletin 849 for on-delay or off-delay. Range from 1/20 to 180 sec ±10%.

ALLEN-BRADLEY
Quality Motor Control



World's longest push button panel? Six such control stations, each with this array of Allen-Bradley push buttons plus pilot lights, are used to select and operate cutters.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

5-59-MR

considerable extent, and for that reason will not be treated in detail here. Instead, sources of design material are given, which provide details and data needed for the design of such systems.

Street and Highway Lighting—The Illuminating Engineering Society sponsored an "American Standard Practice for Street and Highway Lighting," which was approved by the American Standards Association, Inc. on February 27, 1953. This Standard Practice classifies luminaires according to light distribution patterns, and gives recommended footcandle values for various densities of vehicular and pedestrian traffic, including mounting heights, spacings, and layouts for luminaires. These Standards are available from the Illuminating Engineering Society and the American Standards Association, Inc. Manufacturers of street and highway lighting equipment classify all luminaires in accordance with the IES Standards, and can also supply layout and design data and information.

The Street and Highway Lighting committee of the IES has under active study a revision of the American Standard Practice of Street and Highway Lighting, based on studies by Dr. H. R. Blackwell.

Sports and Recreation—A wide variety of open and enclosed types of floodlights are available, for all types of light sources, for all classes of sports and recreation lighting, from several manufacturers of outdoor lighting equipment. Lighting design techniques are given in the *IES Lighting Handbook*, and they are available from equipment manufacturers.

The Illuminating Engineering Society also has a Recommended Practice for Sports and Recreation Lighting, and this practice is being revised. The new revised edition should be available late in 1959.

Floodlighting—Floodlighting is used for a wide range of applications, including: buildings, monuments, swimming pools, gasoline service stations, used car lots, outdoor signs, construction projects, storage yards, railroad yards, decorative effects, protective lighting, loading docks, etc. Lighting design procedures are given for most of these applications in the 1959 *IES Lighting Handbook*, and from the manufacturers of outdoor lighting equipment. Many of these applications will lend themselves to special lighting treatments, which should be considered whenever applicable.

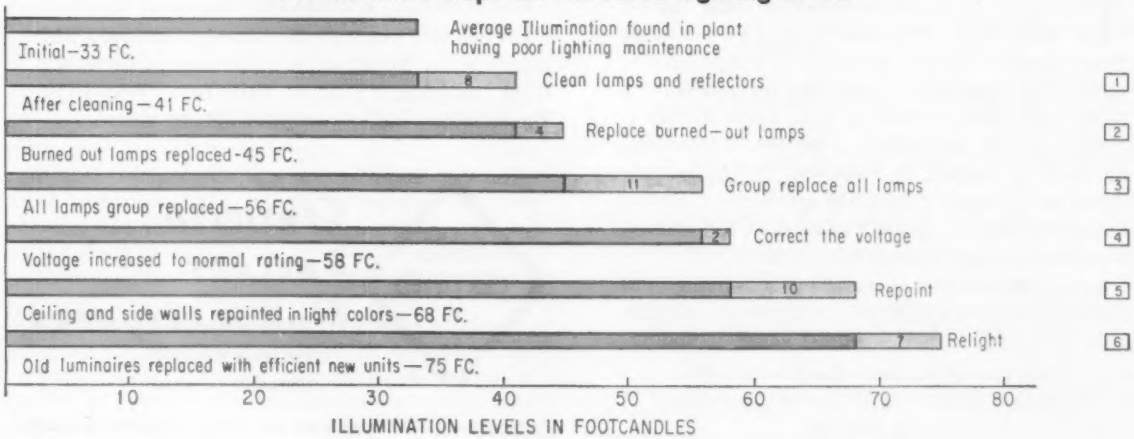
Lighting Maintenance

A factor in lighting system design which in general receives far too little attention is that of lighting maintenance. This is a factor which the lighting engineer can, and should, do something about. What he can do will be limited, of course, to the inclusion of features and provisions for making maintenance simple, easy, and inexpensive. Responsibility for the use of these features and provisions, after the lighting system is installed, will rest with the owner.

Two approaches to this problem are available to the lighting engineer. One approach is to select luminaires and lighting equipments which include easy maintenance features designed and built into the units by the lighting equipment manufacturers. Such features include: quick, safe and easy relamping; readily accessible components, such as lampholders, ballasts, wiring; easily removed reflectors, diffusers, louvers; use of quality reflectors, which can be restored to original efficiency by damp cloth or washing; use of diffusers which are destaticised, light-stable, and which can be easily cleaned; use of light-stable plastic louvers, or metal louvers which have a tough and durable finish; etc.

The second approach is to provide easy access to all lighting equipment. This means keeping mounting heights low enough for the luminaires to be readily reached from ladders, of using recessed equipment which permits easy access to lamps, reflectors, ballasts, etc., of providing catwalks, hinged units, lowering devices, etc., for luminaires, reflectors and equipment installed in medium and high bay areas and in high ceilings where ladders, upright scaffolds, etc. would not be practical.

Maintenance Steps for Increased Lighting Levels



HOW CBM ASSURES YOU BETTER BALLAST VALUE

Unannounced visitor picks random samples from production line of each Certified Ballast Manufacturer for monthly ETL test . . . so you can be sure CBM symbol always means "up to specification"

THIS gives you *extra* assurance of CBM quality. At least once each month, an ETL inspector "just happens" to visit the plant of every Certified Ballast Manufacturer . . . and picks random samples right from the production line. Each sample is clearly marked and dated to prevent substitution; all must be shipped to Electrical Testing Laboratories for test against the CBM specification. Should any fail to meet it, the right to use the CBM emblem is withdrawn until the condition is corrected.

Behind this positive assurance of continuing CBM quality is the CBM specification, that provides dependable performance, better ballast value, including:

High power factor • Long ballast life
High light output • Low cost of illumination
Long lamp life

And of course, Certified CBM Ballasts are UL listed.

For one very practical slant on why Certified CBM means better ballast value and better performance from fluorescent fixtures, write for: "Why High Power Factor Ballasts cut your lighting costs".

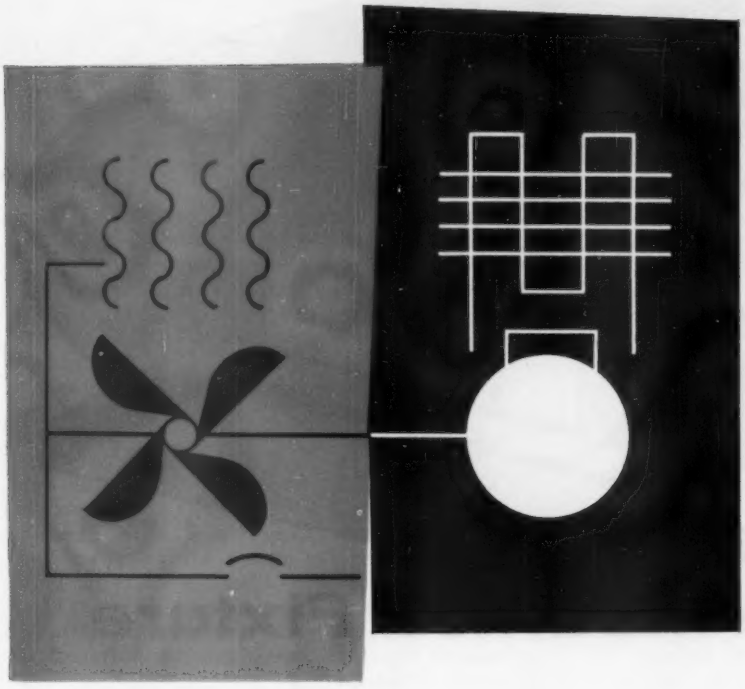
CBM CERTIFIED by ETL

CERTIFIED BALLAST MANUFACTURERS

2118 KEITH BUILDING
CLEVELAND 15, OHIO

Participation in CBM is open to any manufacturer who wishes to qualify

5-59



USE MODERN DESIGN FOR . . .

HEATING AND AIR CONDITIONING

ELECTRICAL engineers designing heating and air conditioning installations will normally do so in conjunction with manufacturers' engineers, since much of the equipment is designed for system operation rather than as isolated components.

Design considerations involved in sizing electric heating and cooling equipment for comfort conditioning of buildings are beyond the scope of this manual. However, since electrical men are becoming increasingly involved in the engineering, specifying and installation of electric heating and air conditioning equipment, many are becoming proficient in the principles of heat transfer, humidity control, and other factors affecting the selection of equipment capacities. For a thorough treatment of these subjects the reader is referred to such standards as the *Heating Ventilating Air Conditioning Guide* published by the American Society of Heating and Air Conditioning Engineers, New York.

Only those factors affecting the design of electrical wiring to such equipment, which differ in some respect from the general procedures discussed in earlier sections of this manual, will be considered here.

Selection of Equipment Capacities

The following general procedure is necessary to size space heating and cooling equipment and must precede all considerations of electrical loads and circuiting for such equipment:

1. Investigation of climatological data to determine design temperature conditions.
2. Investigation of building construction to determine heat transmission coefficients of wall, ceiling and floor sections.
3. Calculation for each room or area to be heated (or cooled) of heat loss (or gain) due to conduction, convection, or radiation through building materials.
4. Choice of general type of equipment to be used.
5. Selection of equipment ratings corresponding to calculated heat loss (or gain).
6. Selection and location of thermostats and other controls required to insure the maintenance of design conditions.

Recommendations must also be made during the construction phase as to the type and quantity of thermal insulation required for efficient operation of equipment.

go modern with a Sylvania Surface Mounted Fixture

Sylvania offers *two* attractive series of shallow, surface mounted fixtures . . . the *Mohawk* and the *Seneca*.

From these two fixture families you can choose appropriate lighting units for modern low ceilings . . . and to match the proportions of almost any room. You have an extensive selection of widths, of shielding media and of lamp types to practically custom-design every lighting installation.

Take a look at some of the outstanding features of these two fixture families. Then keep Sylvania in mind the next time you have an installation that calls for surface mounted units.

These two fixture series typify the broadness of Sylvania's entire line of modern fluorescent lighting equipment. To bring yourself up to date on the most complete fluorescent fixture line in the industry, write today for a catalog of Sylvania's Lighting Fixtures and Systems.

SYLVANIA LIGHTING PRODUCTS
A Division of SYLVANIA ELECTRIC PRODUCTS INC.
Department 59-5
One 48th Street, Wheeling, West Virginia

Sylvania's MOHAWK Series

This series of shallow fixtures comes in two widths. The *Chief* is a nominal 1′ wide and uses two lamps. The *Super Chief* is available with either four or six lamps in a nominal 2′ width.

All units of the MOHAWK Series feature sturdy "wrap-around" chassis with ribbed plastic side panels. These polystyrene side panels illuminate the surrounding ceiling area to minimize brightness contrasts with ideal blending of fixture and ceiling.

Through the use of a smooth fitting, hidden-hinged shield frame, the MOHAWK provides a wide selection of shieldings in plastic, metal and glass, to fit individual shielding preferences.

Sylvania's SENECA Series

The SENECA features a dished panel of acrylic plastic which fastens directly to the fixture body without extra supporting devices. The resulting clean lines present a smart appearance which harmonizes with modern interiors. Together with soft, diffused illumination, the fashionable appearance of the SENECA makes it the ideal fixture for many stores and offices, both large and small.

The availability of three different widths in this versatile, solid-sided fixture series—13⅜″ with two lamps; 15⅛″ with four lamps; 23¾″ with six lamps—makes it simple to select the fixture width for the desired illumination level and room appearance.

GO MODERN WITH LIGHTING BY **SYLVANIA**

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

FLUORESCENT LIGHTING FIXTURES AND SYSTEMS • BEST FIXTURE VALUE IN EVERY PRICE RANGE

Electric Heating

For the great variety of industrial applications of electric heat, requirements may be summarized generally by (1) the amount of heat necessary to raise the solid, liquid or gaseous material involved to the operating temperature and (2) the heat required to maintain this temperature.

Due to the heat retentivity of building materials and the continuous nature of space heating loads, the initial heat to bring the space to temperature is not normally considered, design being based merely on the heat necessary to offset that lost by convection, conduction and radiation through the building itself to the outside.

Equipment capacities for electric space heating applications are usually figured quite closely. Industrial and commercial users are faced with higher operating costs due to electrical demand charges, and effort is made to keep continuous loads as low as possible, consistent with actual requirements. Excess capacity would require extra means of control to regulate the amount of connected load operating at any one time.

In industrial heating processes, on the other hand, a safety factor in the vicinity of 20% over-capacity is frequently adopted. Depending upon the specific process, factors often are present which cannot be forecast exactly, such as heat losses from exposed surfaces of equipment, heat absorbed by conduction to auxiliary apparatus, etc. Since most processes already include some form of control equipment, these controls serve to limit the kwhr consumption at any one time to that required without penalty.

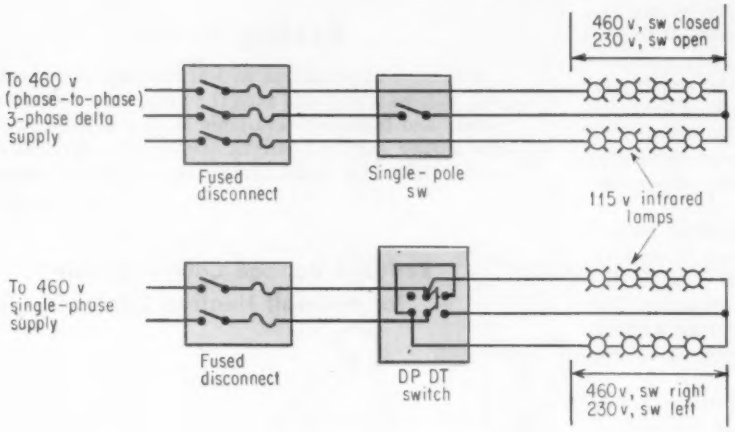
Infrared Heating

Industrial heating applications employing infrared lamps take advantage of the high percentage of infrared radiation emitted despite their relatively low operating temperature. Installations consist of one or more infrared lampholders wired in sections, panels or strips arranged so as to direct the radiant output of the lamps onto the surface to be heated. Since lampholders will be subject to high temperatures at close spacing for long periods of time, a good grade, one-piece porcelain shell type should be specified for the screw-base lamp of 300 watts or less. Larger lamps having the medium bipost base are usually connected to the branch circuit using braided wire welded to the base posts.

Standard switching and control equipment may be used. Where conveyors are used, interlocked circuits should be provided to disconnect lamps when conveyor stops to avoid extreme concentrations of heat.

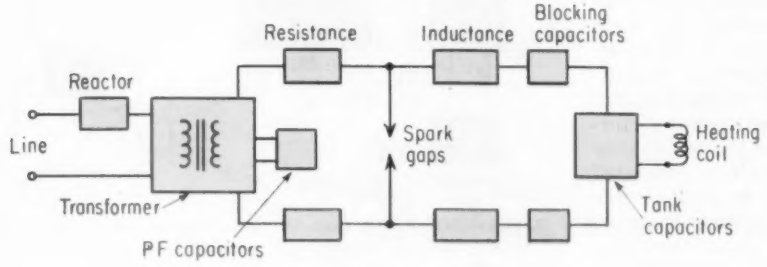
Lamps rated at 115 volts may be used on higher-voltage circuits by connecting several in series to make up the circuit voltage. Lamps are rated at several voltages in the 100-130-volt range to permit selection of voltages which will add up close to the actual circuit voltage and thus permit operation of

Switching Control of Infrared Lamp Output



INFRARED HEATING output may be cut in half through use of disconnect switch in one phase on 3-phase delta system (top) or by series-parallel switch on single phase circuit (bottom).

Induction Heater Supplied by Spark Gap Converter



SPARK GAP CONVERTER used for induction heating operates on parallel-resonant tank circuit principle; inductance coils are tuned for maximum output in heating coil. High voltage is generated across series-connected spark gaps.

the lamps at their maximum efficiency. Where series operation is used, the lampholders must be rated for the circuit voltage, not the lamp voltage (National Electrical Code Section 4237).

Although series operation results in lower wiring and equipment costs, the inconvenience of loss of heat from several lamps for each burnout and the subsequent searching for the faulty lamp may make 115-volt circuits (provided through the use of transformers, if necessary) desirable.

Variation of heat output is frequently obtained through use of a series-parallel switch to provide half voltage across the lamps on single-phase circuits. On 3-phase 460-volt delta systems, four 115-volt lamps may be connected across phases a and b and four lamps across phases b and c, half-voltage being obtained by switching phase b as shown in accompanying diagram. Heat is also varied by varying the speed of the conveyor carrying the "charge", or material to be heated. Maximum rating of branch circuits feeding infrared lamp sections is 50 amps (Sec. 4242).

These wiring requirements apply also to tubular quartz lamps, which provide higher concentrations of energy than standard infrared lamps, except that all connections are made to branch circuits by splicing to lamp end leads. Lamp wattages vary directly with length of filament and consequently with operating voltage. The 500-watt lamp operates on 115-125 volts, the 1000-watt on 230-250 volts, the 2500-watt on 460-500 volts, and the 5000-watt on 920-1000 volts.

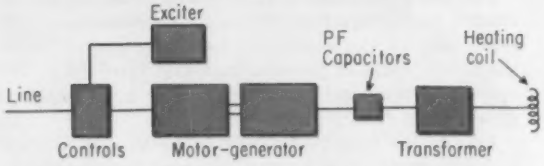
Induction and Dielectric Heating

Induction heating equipment uses an alternating magnetic flux to induce eddy currents within the mass to be heated. Frequencies of from 60 to several megacycles are used, depending upon economic factors of the generating source and the nature and configuration of the heated material. Apparatus used to produce the desired frequency includes rotating machines (usually a high-cycle generator driven by a 60-cycle motor), sparkgap apparatus, and electric oscillators.

The mass to be heated (charge) requires no terminals to be connected to it, but it must be an electrically conductive material. A coil around the charge is essentially a transformer primary, the induced current in the charge representing a short-circuited secondary and the heat absorbed by the charge is the output.

Production layouts and space limitations dictate the location of the power-generating equipment, which is often isolated from the heating apparatus (load applicator). This introduces special problems of transmission of the current from the generator to the applicator, since conductor reactance at high frequencies become a major consideration. Both insulated and uninsulated conductors are used, depending upon conditions under which the installation is to be made, the costs of installing the conductors, and the cost of the required power-factor-correcting capacitors. Bare conductors are usually hollow, of round or square cross-section. Insulated coaxial conductors are often used because of ease of installation; however, their current-carrying capacity is lower than equivalent sized bare conductors. Since transmission of the generator output to the load applicator has such a direct bearing on proper operation of the equipment, details on conductor types and sizes to be used will invariably be specified by the equipment manufacturer.

Induction Heater Using Rotating Frequency Converter



M-G SETS used for induction heating applications are available in capacities of 5 to 500 kw or more at various frequencies.

Dielectric heating is used for non-conducting materials. Heating is accomplished by placing the material between two conducting surfaces carrying an ac radio-frequency current, the entire set-up resembling in its operation a large capacitor. Electronic equipment is used to produce the radio-frequency currents required for operation.

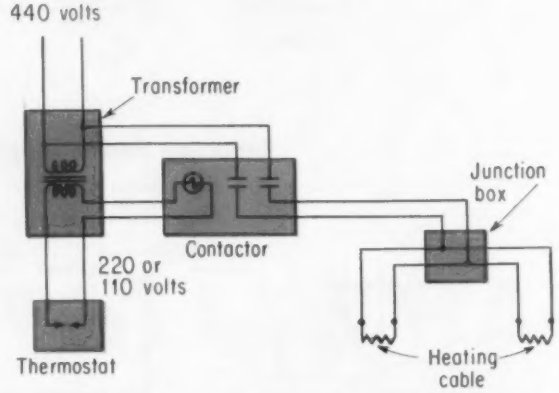
Unlike induction heating apparatus, the high-frequency generating source is not remotely located; hence only conventional power feeders are involved. Special controls and safeguards required are built in or supplied by the manufacturer.

Code Article 665 contains miscellaneous provisions governing supply conductors, protection, control and grounding of induction and dielectric heating equipment.

Heating Cable

For such applications as soil heating, snow melting, slab warming and pipe thawing, special heating cables and tapes are available having a fixed wattage rating per unit length. Designs incorporating such cable must make provisions for use in stand-

Reduced-Voltage Control Circuit for 440-volt Heating Cable



TRANSFORMER is used for control circuit where thermostat is employed on heating cable installations over 200 volts.

MANUFACTURERS OF ALL TYPES OF INSULATED WIRE & CABLE
HATFIELD WIRE & CABLE
DIVISION OF CONTINENTAL COPPER & STEEL INDUSTRIES INC
PLANT AND EXECUTIVE OFFICE
HILLSIDE NEW JERSEY
DISTRIBUTORS' COMPOSITE DIAMETER & WALL THICKNESS CHART
SEE YOUR HATFIELD REP
FOR THE BEST DEA
COIL OR REEL

one sheet covers almost everything

Here's another Hatfield first. Our Composite Data Charts are masterpieces of simplicity . . . reducing as much as 50 pages of wire and cable information into **a single sheet!**

ONE PRICE SHEET . . . gives list prices, stranding, strand diameters, plus temperature ratings, cutting and paralleling charges.

ONE WEIGHT AND PUT-UP SHEET . . . gives net weight, standard shipping weight, standard put-ups and reel deposits.

ONE DIAMETER AND WALL THICKNESS SHEET . . . gives overall diameter and insulation plus jacket wall thickness.

ONE SPECIFICATION SHEET . . . gives listing of most common specifications and their issuing agencies.

Everything you need at your fingertips! Ask your Hatfield representative or write us for your free copies.

MANUFACTURERS OF ALL TYPES OF INSULATED WIRE & CABLE

HATFIELD WIRE & CABLE

DIVISION OF CONTINENTAL COPPER & STEEL INDUSTRIES INC.

Plants • Hillside • Union • Linden

Executive Offices • Hillside, New Jersey

PITTSBURGH STANDARD HOT-DIP GALVANIZED CONDUIT IS RUSTPROOF FROM END TO END

The zinc chromate coating that characterizes Pittsburgh Standard Hot-Dip Galvanized Conduit doubles the protective life of the galvanizing. And the hot-dip galvanized and coated threads stay bright, clean and sharp. No chasing or cleaning required even when conduit lies in storage for months. All thread protectors are color-coded for easy size identification.

For ease in handling, Pittsburgh Standard conduit is banded into master lifts, and the individual bundles of each size are identified by color-coded bundling tapes. All these features are yours at no extra cost when you buy Pittsburgh Standard. Ask for them at your electrical distributor's. *Pittsburgh Standard Conduit Company, Verona, Pa.*

PLANTS AT VERONA AND MORRISVILLE, PA.

RIGID STEEL CONDUIT · ELECTRICAL METALLIC TUBING · ELBOWS · COUPLINGS · FITTINGS

ard manufactured lengths for the supply voltage contemplated, since any deviation in length for a given voltage will affect heat output and cable life. For example, if only 90 ft of a 100-ft cable designed to provide 1000 watts of heating at 230 volts were used, the total power consumed would be 1100 watts at greater-than-normal current. Since this is likely to affect the life of the insulation and since the application involved may make replacement difficult and costly, proper initial design is imperative.

Cable manufacturers supply information on correct cable spacing for various heat outputs. Where thermostats are to be used on installations employing voltages over 220 volts, step-down transformers are used for control circuits.

Circuit Design

Heating circuits are designed in accordance with branch circuit and feeder provisions of NEC Articles 210, 220 and 240 plus applicable portions of Articles 422 and 430. Miscellaneous problems and applications which arise require comment.

Derating

Whereas some specific industrial heating installations (furnaces, immersion heaters, etc.) are such as to make it impossible to operate all equipment simultaneously, accurate diversity information on the heating load supplied is frequently unavailable. Where such is the case, branch circuits feeding heating equipment are assumed to be carrying a continuous load, and, to compensate for increased heating and its effect on the over-current device and panel enclosure, the total load must not exceed 80% of the circuit rating (Sec. 2125b).

Space-heating circuits subject to thermostat cycling may be loaded to 100%; however extra capacity should be provided to take care of initial surge currents which frequently reach values from 50 to 100% above rated current and persist until operating temperature is reached.

Feeder loads are computed as 100% of the total connected load on all branch circuits served by the feeder. If however, an accurate determination can be made of intermittent operation of the heating load which shows that only a definite portion of the load is energized at one time, the code-enforcing authority may permit feeder conductors to be of a capacity less than 100% (Sec. 2203h). From a design standpoint, the 100% figure should be specified unless definite diversified operation makes such a procedure clearly economically unfeasible.

Where four or more current-carrying conductors occupy the same conduit, standard derating factors must be applied in accordance with Notes 4 and 5 of Code Table 1.

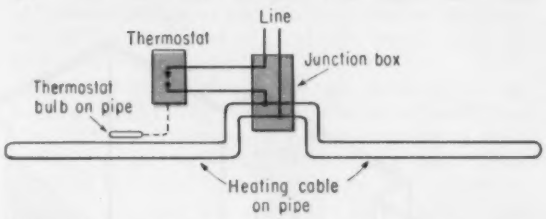
Well designed space heating installations will normally include several inches of thermal insulation in the ceiling. Electrical conductors located within such insulation over electrically heated ceilings are considered to be operating at an ambient temperature of 50 C and must be derated in accordance with Notes 4 and 5 of Table 1. Plans for such installations should specify that all wiring be located above the insulation to avoid derating.

Voltage Drop

Sec. 2202 requires feeder conductors to be such that voltage drop up to the final distribution point for the computed heating load will be not more than 3%. However, since the heating effect of current through a resistance varies as the square of the voltage, a 3% reduction from rated voltage results in a considerable reduction in heater output from rated conditions. Efforts should be made to keep the drop below 2%—not to the final distribution point, but to the actual utilization device.

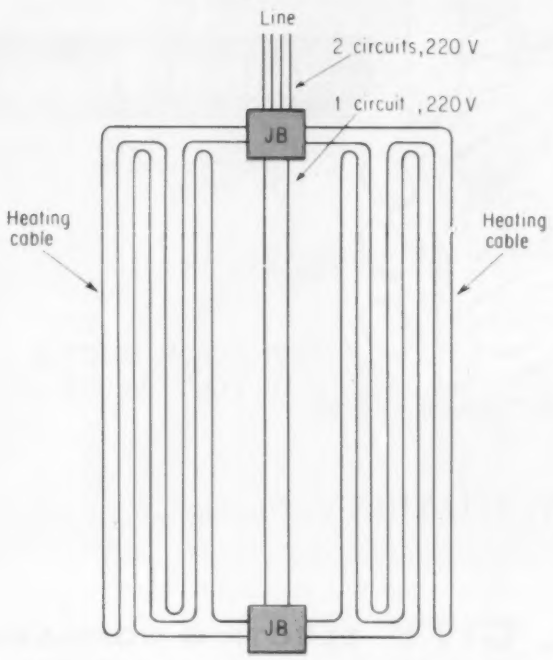
The accompanying chart shows the effect of voltage drop on heater output. The center curve shows actual wattage furnished by a 2000-watt, 208-volt heater at various voltages, assuming that the heat-

Thermostat Controlled Heating Cable for Pipe Warming



PIPE HEATING CABLE may be spiraled on pipe at recommended spacing or taped parallel with pipe to reduce labor. Thermostat bulb is normally fastened to pipe surface beneath insulation, if used.

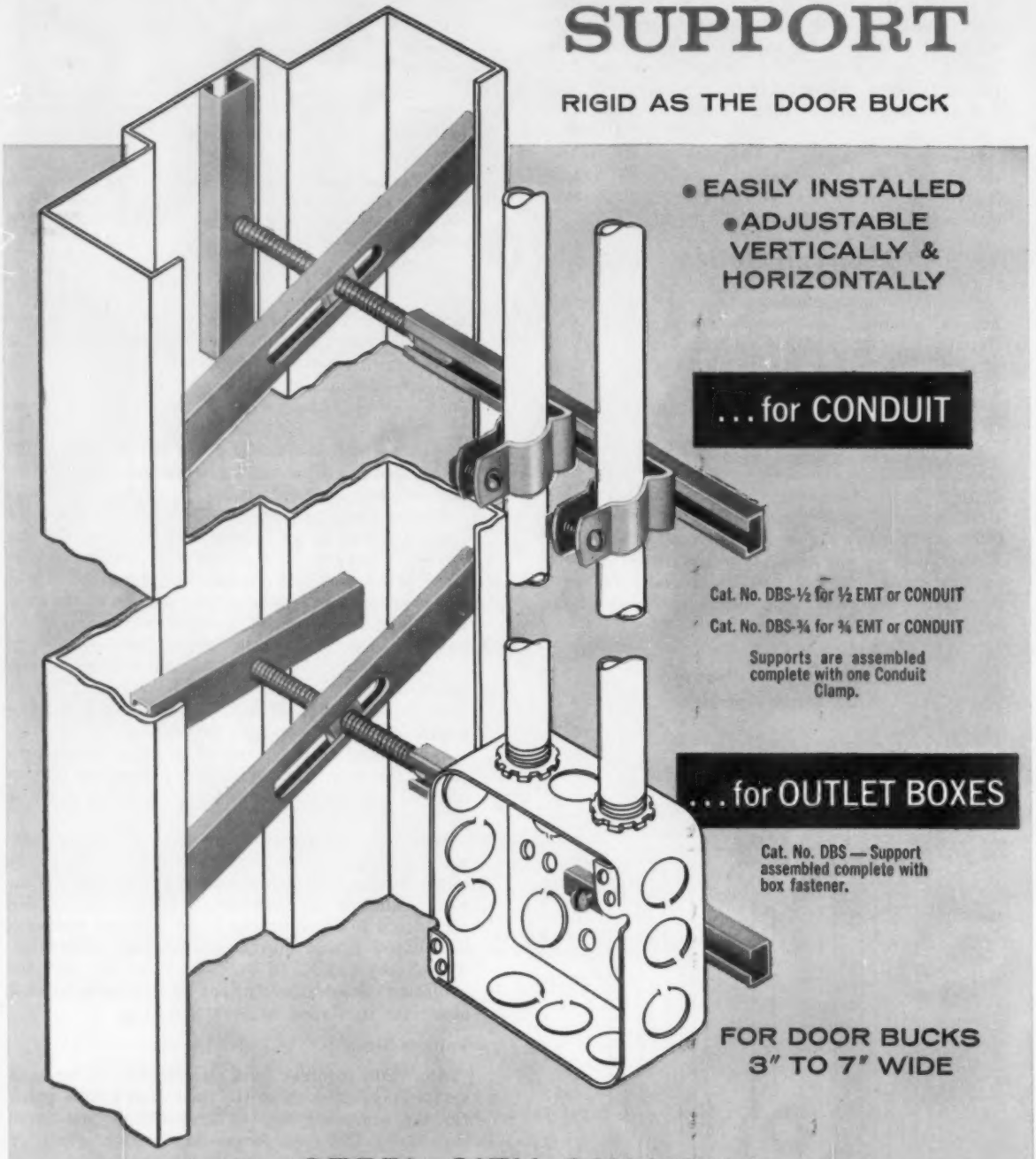
Cable Layout Provides Two Stages of Heat



TWO CIRCUITS of heating cable for driveway snow melting give two stages of heat for light and heavy snowfalls. Such circuits are normally manually controlled.

STEEL CITY DOOR BUCK SUPPORT

RIGID AS THE DOOR BUCK



- EASILY INSTALLED
- ADJUSTABLE VERTICALLY & HORIZONTALLY

...for CONDUIT

Cat. No. DBS-½ for ½ EMT or CONDUIT

Cat. No. DBS-¾ for ¾ EMT or CONDUIT

Supports are assembled complete with one Conduit Clamp.

...for OUTLET BOXES

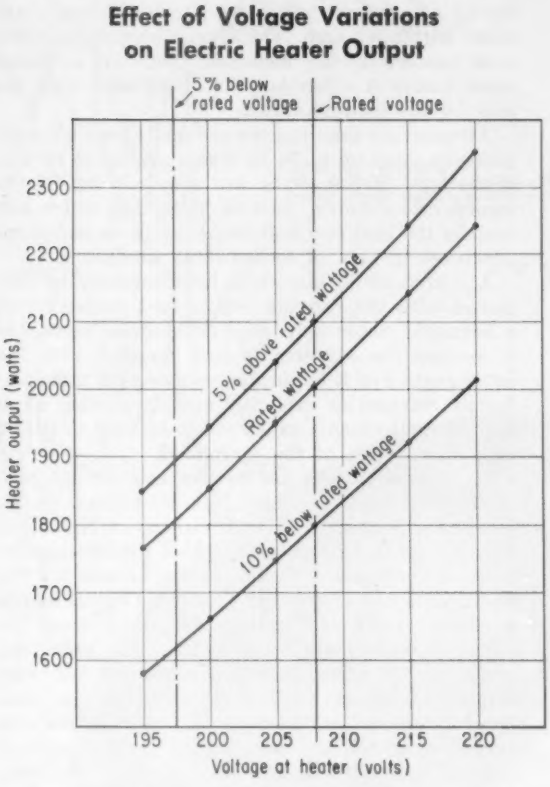
Cat. No. DBS — Support assembled complete with box fastener.

FOR DOOR BUCKS 3" TO 7" WIDE

Another **STEEL CITY QUALITY** Product

WRITE FOR A FREE SAMPLE

STEEL CITY ELECTRIC COMPANY
PITTSBURGH 33, PA.



VOLTAGE DROP may seriously affect heater output. Center curve shows voltage-wattage relationship for 2000-watt, 208-volt heater where heating element wattage is actually rated wattage at rated volts. Upper and lower curves represent possible conditions where element is actually 5% above or 10% below rated value due to manufacturing tolerance. Note that a heater which is 10% below rated would furnish only 1620 watts if 5% voltage drop were involved.

ing element is of the correct resistance to produce the rated wattage at rated voltage. Manufacturing tolerances are such that a 2000-watt heater may actually vary 5 or 10% even at rated voltage. The upper and lower curves of the chart represent conditions at 5% above rated wattage and 10% below.

The curves show that, even if the heater matches its rating exactly, it will furnish only 1805 watts at 5% below rated voltage, which is a drop of 10% in wattage. If the 2000-watt heater furnished for the job happens to be 10% below rated wattage and in addition is connected to a circuit 10% below rated voltage, it will furnish only 1620 watts, almost 20% below design value. Multiply this by the number of heaters involved, and the result could be serious under-capacity.

Where such voltage drops are expected in advance and can not be reduced by increased conductor size, additional capacity must be installed to make up the loss and bring the actual watts up to those required by heat loss calculations. The following formula indicates the procedure to be used in arriving at the total installed watts required where the actual voltage to be available at the heater is other than rated voltage:

$$\text{watts} = \text{calculated watts} \times \left(\frac{\text{rated voltage}}{\text{actual voltage}}\right)^2$$

For example, where 10,000 watts of heating must be operated 3% below rated 208 volts, the installed watts should be

$$10{,}000 \times \left(\frac{208}{201.76}\right)^2 \text{ or } 10{,}630 \text{ watts}$$

to compensate for the 3% voltage drop. Division of these extra 630 watts among the specific areas or rooms to be heated may be impractical due to type of equipment used or ratings available, hence maximum attention should be given in the design stage to developing a feeder and branch circuit distribution plan which will minimize power losses due to voltage drop.

Combined Loads

Normally a heating circuit should not be designed to also feed a lighting load. However, there may be occasions, such as the feeding of a single small unit heater in a factory gate house, where it may be expedient or necessary to pick up the heater load on one of the lighting circuits. Such a practice is recognized by the code.

Code Sec. 2126 limits a fixed appliance load to 50% of 15- and 20-amp branch circuit ratings if lights are also supplied; any one portable appliance is limited to 80% of the circuit rating. On 30-amp circuits, a single portable appliance shall not exceed 24 amps.

In view of the restrictions imposed and the minimum nature of the combined loads permitted, such an arrangement is makeshift at best. Good design should provide individual circuits for heaters.

Air Conditioning

Three principal factors create problems of circuit design in air conditioning wiring which are not normally encountered with other utilization equipment: (1) Extensive use of hermetic compressors and associated equipment has made inapplicable the horsepower-current relationships identified with conventional motors. (2) Most equipment incorporates two or more motors, creating problems of group protection. (3) The air conditioner exists in several forms which alternately identify it as an appliance and as a straight motor load, making consistent and direct application of present National Electrical Code provisions difficult.

The main objective of any air conditioning installation is to provide maximum reliability and effectiveness of operation, consistent with economy and applicable safety codes. The electrical engineer, contractor and inspector, to do their part in accomplishing this objective, must see eye-to-eye in the installation of the equipment furnished and its compliance with the code.

Fundamentally, the circuiting of every air conditioning installation involves consideration of each of the following: (1) motor running overcurrent protection; (2) unit controller and disconnect; (3) feeder and branch circuit conductors; and (4) feeder and branch circuit protection.

Motor Overcurrent Protection

Motor overcurrent protective devices are necessary to protect the motor, its associated controls, and the branch-circuit conductors against heat damage due to excessive motor currents. High currents may be caused by the motor being overloaded for a considerable period of time, by consistently low or unbalanced line voltage, by single-phasing of a polyphase motor, or by the motor stalling or failing to start.

Damage may occur more quickly to a hermetic motor which stalls or fails to start than to a conventional open-type motor for two principal reasons: (1) Due to the presence of the cool refrigerant atmosphere under normal conditions, a hermetic motor is permitted to operate at a higher rated current which is closer to the locked-rotor current than is the rated current of an open-type motor of the same approximate size. (2) With the rotor at a standstill, there is no circulation of the refrigerant to carry away the heat; and the heat builds up in the windings.

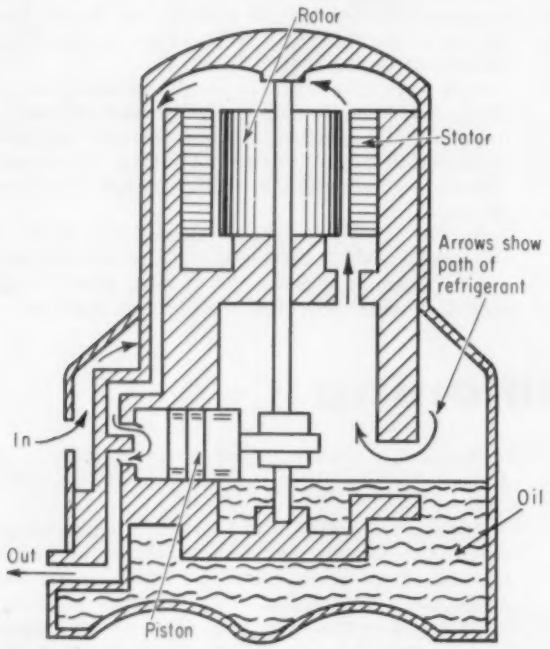
Special quick-acting thermal and hydraulic-magnetic devices have been developed to reduce the time required to disconnect the hermetic motor from the line before damage occurs when an overload condition develops. The appropriate current rating of overload protectors is critical; many are rated within 0.1 amp. Therefore, the running overload protection for hermetic units or packaged conditioners is either built in or supplied with the unit by the manufacturer.

All room air conditioners and packaged unit compressors rated up to 30 hp which are listed by Underwriters' Laboratories are required by UL to incorporate running overload protection which will restrict the heat rise to definite maximum safe temperatures in case of locked-rotor conditions.

A contractor or electrician will normally be concerned with the running overcurrent protection of a hermetic motor only when it becomes necessary to replace the existing devices supplied with the equipment. For this purpose, compressor manufacturers' warranties explicitly specify catalog numbers of replacements which are to be used to insure proper operation of the equipment.

To determine whether proper overcurrent protection has been provided, the electrician or inspector is guided by the provisions of NEC Sec. 4322-a-1, 4322-c-1 and 4324, which incorporate Interim Amendment 104. The heater chosen for the hermetic motor starter must be rated or set at not more than 125% of the motor full-load current for hermetic motors having a locked-rotor value not exceeding 160 amps. For larger ratings, the overcurrent size must not exceed 115%. If the computed value does not correspond to a standard size protective device, the next higher available rating may be used, with an absolute maximum of 140% for hermetics up to 160 amps locked rotor, and 130% for larger ratings.

Construction of Hermetic Motor



HERMETIC MOTOR is completely sealed within compressor housing. Cool refrigerant is directed through motor windings in path through compressor, as shown by arrows.

Controller and Disconnect

The NEC in Sections 4403b and 4383e outlines the method to be used for determining the minimum safe ratings of controllers and disconnects for hermetic motors. Controllers encountered in packaged air conditioning equipment are for the most part across-the-line magnetic starters operated by some type of selector switch, pushbutton station, time clock or thermostat. Smaller window units use only a selector switch with necessary starting relays. This control equipment is normally furnished by the manufacturer and often is supplied completely wired and built into a control panel in the conditioner.

Starters used for ac motor loads must be able to carry continuously the full-load current of the motor and must be able to interrupt the stalled-rotor current if necessary (NEC Section 4382). Standard motor starters are normally rated in horsepower and are designed to handle the usual current-carrying and current-interrupting capacities associated with the horsepower rating.

For example, a 3-phase controller rated at 5 hp is capable of starting and stopping a standard 3-phase, 5-hp motor (7.5 amps running current) and of interrupting the locked-rotor current (approximately 45 amps) if required to do so. Selection of a controller for a standard motor, then, is strictly on the basis of the horsepower of the motor to be controlled (plus the particular operations that the controller must perform—stopping, starting, reversing, etc.).

SAFE and SURE

... AS A SLIPKNOT SPLICE

DEPENDABLE ADHESION . . .
NEVER DRIES OUT

WHAT do *you* look for in friction tape? Such a small part of the total job cost, yet so *vital* . . . each splice you make must be *final, permanent* and *safe.* In the long run, SLIPKNOT quality — tape that never dries out — that *stays* on the splice — costs you *less.*

Expert electricians know that SLIPKNOT FRICTION TAPE has never failed . . . that's why it's the most widely used friction tape in the world . . . why it's *found in all the best splices.* It should be in all of yours.

Next time, *specify* SLIPKNOT from your distributor.

SOLD ONLY THRU RECOGNIZED WHOLESALERS

59A

PLYMOUTH RUBBER COMPANY, INC.
QUALITY SINCE 1896 CANTON, MASSACHUSETTS

Balance . . .

what does it mean in cable?

No one characteristic alone determines good cable. It's the right balance of many qualities that counts. Carol *has* this balance. Look at these significant test results.

	BRAND			
	CAROL	A	B	C
Electrical Insulation Resistance (1)	100	17	16	68
Cold Bend °F (2)	−50	−45	−90	−50
Abrasion Resistance (1)	91	62	100	92
Ozone Resistance (1)	100	6	18	12

Note: (1) 100 indicates best—others % of best (2) cold bend—actual test temperature

As can be seen, needlessly high cold flexibility can be built into cable . . . but only at the sacrifice of more important electrical properties. And in Brands A, B and C you will also note the lack of balance between abrasion resistance and ozone resistance . . . which means these cables can crack long before they wear out.

Carol, on the other hand, has not only the highest *combined* rating but is also the best *balanced*. As a result of years of experience and research, primary emphasis has been placed on the characteristics most vital in cable life and performance.

To you, this means superior quality *throughout* . . . *extra* quality and performance where it is most needed.

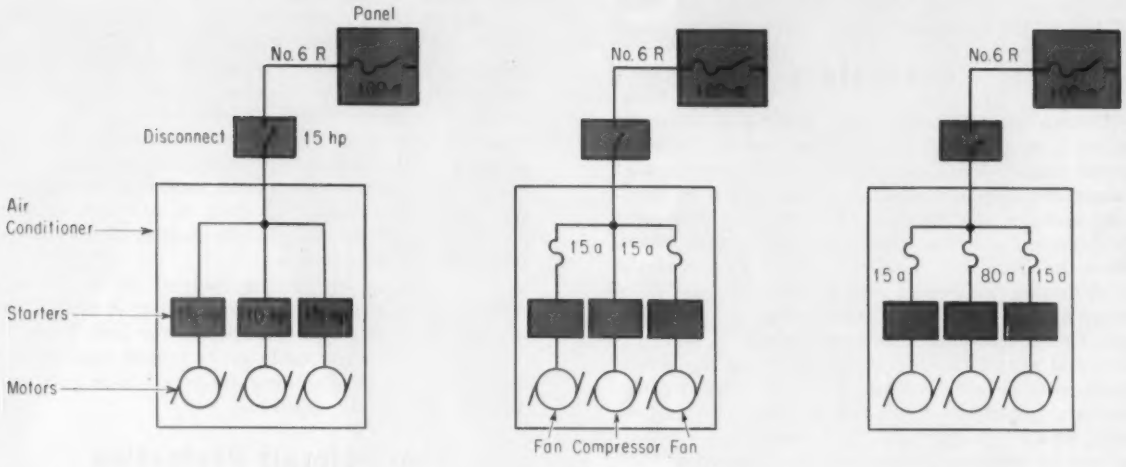
when you call for cable— call for

Carol®

CAROL 14/3 SO NEOPRENE 600V

PORTABLE CORDS • POWER SUPPLY CABLE • CONTROL CABLES • WELDING CABLE • GOVERNMENT TYPES • CORD SETS

Calculation for Sizing Circuit Conductors, Protection and Controls



All Motors on Same Circuit | Separate Fuses for Fans | All Motors Fused

Motor Data:

Condenser and Evaporator Fans	Compressor
1½ hp, 220-volt, 3-phase	220-volt, 3-phase
4.4 amps full load	26 amps full load
35 amps locked rotor	150 amps locked rotor

All Motors on One Circuit

Branch-circuit fuses:

Sec. 4343: (300% × 26) + 4.4 + 4.4 = 86.8 amps
May use 100-amp fuses, subject to group fusing restrictions of starters.

Circuit conductors:

Sec. 4314: (125% × 26) + 4.4 + 4.4 = 41.3 amps
Requires No. 6 R (or No. 8 RH)

Compressor starter:

Sec. 4383e: Tables 24 and 25; 10 hp required.

Fan starters:

Sec. 4383: 1½-hp motors require 1½-hp starters.

Disconnect:

Sec. 4403b: Tables 24 and 25: 15 hp required.
Note: If motors do not start simultaneously, the compressor locked-rotor current (150a) used with Table 25 indicates a 10-hp rating. However, the sum of the running currents impose the more severe requirements and dictate the switch size.

Separate Fuses for Fans:

Fan fuses:

Sec. 4342: (300% × 4.4) = 13.2 amps
May use 15-amp fuses.

Other circuit values unchanged.

All Motors Fused:

Compressor fuses:

Sec. 4342: (300% × 26) = 78 amps
May use 80-amp fuses.

Other circuit values unchanged.

However, hermetic motors are not rated in horsepower, but in terms of running current and locked-rotor current. Thus, the required horsepower rating of the starter is not immediately apparent. The NEC stipulates (Sec. 4383e) that when a controller is to be procured for a hermetic motor and the controller is rated in hp, Tables 22, 23, 24 and 25 are to be used to establish hp rating.

For example, a 3-phase, 440-volt hermetic motor rated at 11 amps full load and 60 amps locked rotor is to be supplied with a controller. Assume that the controllers to be used are rated only in horsepower. To make sure the controller selected will handle the running current, Table 24 is used. This table lists 7½ hp as the required size for a 440-volt, 11-amp motor. To insure adequate interrupting capacity, Table 25 is used. For a 60-amp locked-rotor current, this table also shows 7½ hp as the required size. Use of both tables in this manner thus establishes the 7½-hp controller as adequate for the given motor in both respects. Had the two ratings as obtained from the two tables been different, the higher rating would have been chosen.

Many starters intended specifically for air-conditioning use are now being rated directly in terms of full-load current and may be selected for particular hermetic motors without reference to horsepower ratings or Tables 22 through 25. Such starters are designed to handle the locked-rotor current normally associated with each full-load current rating.

Disconnects are required by the code for the purpose of isolating motors and their controllers from the circuit (Sec. 4401 and 4402). They are required to be in sight from the motor and within 50 ft. They are not normally supplied by the manufacturer of the air conditioning equipment, since the specific type of disconnect to be used depends upon the distribution system to which the conditioner is to be connected.

Motor disconnects are rated in horsepower and are designed to carry the 115% nameplate current as required by NEC Section 4403a. To relate their horsepower ratings to the current ratings of hermetic motors, Tables 22 through 25 are used in the same manner as for selecting the controller rating (Sec. 4403b).

Where general-use switches or other means of disconnect are used as permitted by the code, they must have a carrying capacity of not less than 115% of the motor full-load current (Sec. 4403a).

Conductors

Branch circuit conductors feeding a hermetic motor load are sized in the same manner as other motor loads (NEC Sec. 4309b; 4312) except that nameplate full-load current values must be used. The problem of continuous loading should be kept in mind and sufficient conductor capacity provided, since the nameplate full-load current rating of the conditioning motors is not a constant maximum value during operation. This rating is established and tested under standard conditions of temperature and humidity. Operation under weather conditions more severe than those at which the ratings are established will result in a greater running current, which can approach the maximum value permitted by the overcurrent device. Operating voltage less than the limits specified on the motor nameplate also contributes to higher full-load current values, even under standard conditions.

Motor feeders are sized according to Sec. 4314. Since overcurrent protection may permit motors to run continuously (up to 140% full load) overloaded, the feeder must be sized to handle such an overload. By basing the calculations on the largest motor of the group, the extra capacity thus provided will normally be more than enough to handle any unforeseen overload on the smaller motors involved, enough diversity existing in any normal group of motors to make consistent overloads on all motors at one time unlikely.

However, a group of air-conditioning compressor motors all of the same size on a single feeder have a common function: reducing the ambient temperature. Except for slight possible variations, weather conditions affect each conditioner to the same degree and at the same time. Therefore if one unit is operating overloaded, it is likely that the rest are also.

This factor should be taken into consideration when sizing air conditioning feeders. Recognition for feeders of the 80% loading imposed on branch circuits (Sec. 4293), even though variations of demand may be expected due to on-and-off compressor operation, will result in improved operation under extended periods of overload or unexpected undervoltage.

In connection with feeder loading, the air conditioner has been added by the code to the group of fixed appliances which may not be considered in applying the 75% demand factor accorded four or more fixed appliances in computing feeder sizes for single or multi-family dwellings (Sec. 2203e). This section goes on to say that, in adding branch circuit loads to determine the feeder load, the smaller of two dissimilar loads may be omitted from the total where it is unlikely that both of the loads, such as an electric heating load and an air cooling load, will be served simultaneously.

There are instances when heating and air conditioning may be required at the same time. Sections of the country having extreme fluctuations of temperature within a 24-hour period may require air conditioning on the sunny side of a building for a short period of time while the other side, without sun, may still be chilly enough to require heat. Another exception could occur when electric heating is used to reduce the effects of air conditioning. There are installations where (due to existing capacities of conditioning equipment, economical limitations of control facilities, or configuration of the building involved) some rooms or areas in the building prove to be too cool when the major portion of the building is at a comfortable temperature. It is sometimes simpler to provide local heat with electric heating units rather then to attempt major modification of the air conditioning system to correct these inconsistencies.

If the heating and cooling loads of the above exceptions were fed by a common feeder, it would be required to have capacity sufficient for both loads.

The accompanying table gives typical unit loads for sizing air conditioning feeders where precise cooling data is not available.

Short-Circuit Protection

Packaged Units

Air conditioning equipment (other than small room units and large custom installations) is manufactured in the form of packaged units having all necessary components mounted in one or more enclosures designed for floor mounting, for recessing into walls, for mounting in attics or ceiling plenums, for locating outdoors, etc.

Electrical wiring in and to these units varies with the manufacturer, and the extent to which the electrical contractor need be concerned with fuse and circuit breaker calculations depends upon the manner in which the units' motors are fed, the type of distribution system used, etc.

Following is a discussion of the most common circuit arrangements and considerations determining choice of short-circuit protection rating.

All motors on one branch circuit: Equipment of this type is tested by Underwriters' Laboratories for conformance with the group fusing requirements of NEC Sec. 4343b. UL Standard 465 on Central Cooling Air Conditioners requires that, where a single branch circuit feeds more than one motor, the maximum permissible fuse size must be indicated on the conditioner or on an attached wiring diagram.

The problem of choosing fuses which will satisfy the group fusing requirements and yet have suffi-

Unit Loads for Sizing Feeders to Packaged Air Conditioners

(Watts per sq ft of conditioned floor area)

Building	Low	Average	High
Banks	4	5	7
Department Stores			
Basement	4	5	10
Main Floor	5	7	12
Upper Floors	3	4	6
Hotel Guest Rooms (per room)	1	1.5	2
Office Buildings	3	4	6
Office Suites	3	3.5	5
Stores	2 to 6	4 to 7	5 to 10
Restaurants	10	15	20
Theatres (watts per seat)			

In Orbit

the
wonderful
WAKEFIELD
prismatic
at a
down-to-earth
price

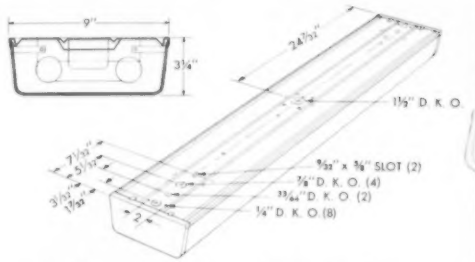
Below: Actual size photograph of clear plastic lens.

the
wonderful

WAKEFIELD® prismatic

TRADE MARK

has rocketed to success . . . hailed by contractors
and users everywhere . . . because it's so beautiful, so practical,
so easy to install and so very, very low priced



Catalog Number	No. of Lamps	Description	Std. Wt.—Lbs. Pkd.	Unpkd.	Pkg. Quan.
R-214	2-F40T12/RS	Wakefield Prismatic	16 30	14 28	1 2

If your customer needs approximately 50 footcandles, install *one* Prismatic for every 40 square feet of area.

Suggest to your customer that he paint his ceiling white and his walls a light color.

eye-fi LIGHTING

Have you seen it yet? It will surprise you. For the Wakefield Prismatic is a quality fixture through and through. Graceful one-piece clear plastic lens diffuser. All steel parts white enameled. Jefferson CBM/ETL, HPF ballast. IBEW, UL/CSA labeled. Takes two Rapid Start lamps. Installs easily directly on the ceiling, singly or in continuous rows.

Distributed by Graybar

Distributed by Graybar houses in over 130 principal U. S. cities and by leading distributors in Canada . . .

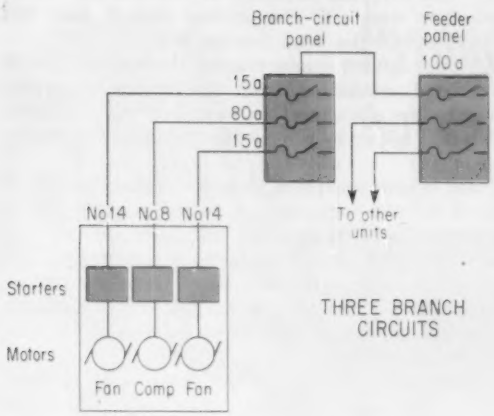
Stores of All Kinds
Supermarkets
Florists
Beauty Shops
Barber Shops
Auto Show Rooms
Restaurants
Banks
Schools
Colleges
Laboratories
Libraries
Offices of All Kinds
Doctors
Dentists
Work Rooms
Repair Shops
Drafting Rooms
Kitchens
Bathrooms

WAKEFIELD

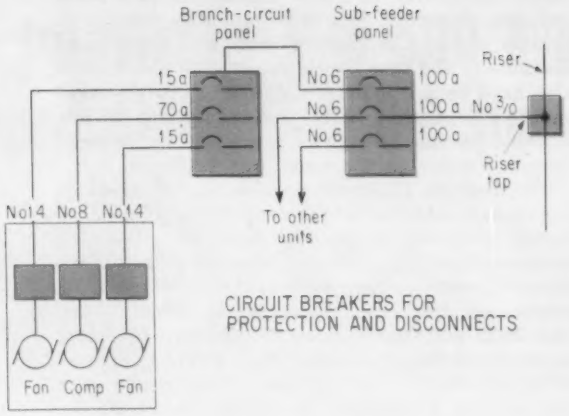
THE WAKEFIELD COMPANY — VERMILION, OHIO
WAKEFIELD SOUTHWEST COMPANY—OKLAHOMA CITY, OKLA.
P.O. Box No. 7147
WAKEFIELD LIGHTING LIMITED—LONDON, ONTARIO

Tear out this page—it's perforated for your convenience.

Calculations Using Separate Circuit for Each Motor



THREE BRANCH CIRCUITS



CIRCUIT BREAKERS FOR PROTECTION AND DISCONNECTS

Three Branch Circuits:

Compressor conductors:
Sec. 4314: (125% × 26) = 32.5 amps
Require No. 8 R or RH

Fan conductors:
Sec. 4314: (125% × 4.4) = 5.5 amps
Require No. 14 R or RH
Other circuit values unchanged

Circuit Breakers:

Compressor CB's:
Sec. 4342; Table 27: (250% × 26) = 65 amps
May use 70-amp CB

Fan CB's:
Sec. 4342; Table 27: (250% × 4.4) = 11.2 amps
May use 15-amp CB

Sub-feeder conductors:
Sec. 4314: (125% × 26) + 4.4 + 4.4 = 41.3 amps
Require No. 6 R (or No. 8 RH)

Sub-feeder CB's:
Sec. 4362: 70 + 4.4 + 4.4 = 78.8 amps
May use 100-amp CB

Riser tap:
Sec. 2434c: 55 × 3 = 165 amps
Require No. 3/0 R (or 2/0 RH)

cient capacity to permit normal operation of the unit without nuisance tripping obviously is one which the manufacturer is better equipped to handle than the man in the field.

The UL *Electrical Appliance and Utilization Equipment List* in its General Information section under "Air Conditioners, Central Cooling" states: "The suitability of motor and branch circuit protection afforded two or more motors operating from a single branch circuit has been covered in these listings and the maximum rating of the branch circuit overcurrent protective device marked on the air conditioner. The proper method of installation (number of branch circuits, etc.,) is shown on the wiring diagram or marking required to be attached to the air conditioner."

Therefore, the electrical contractor and inspector charged with wiring and approving such an installation can be sure that code requirements have been met—provided that the branch circuit protection as specified on the unit is not exceeded and the wiring and equipment is as indicated on the wiring diagram. Provision is made in such a unit for direct connection to the branch circuit conductors; motors are wired internally by the manufacturer.

A typical unit with all motors on one circuit is shown in an accompanying illustration with calculations for determining circuit ratings. As stated above, these values would normally be furnished by the manufacturer and approved by UL and may deviate in certain cases from values obtained by strict application of code provisions.

Separate fuses for fan motors: Units are sometimes encountered in which the manufacturer has wired separate fuse cutouts for the fan motors inside the enclosure to avoid group fusing restrictions. The cutouts are normally fed from the line terminals of the compressor starter. The fan circuits no longer restrict the maximum value of the main fuses. As shown by the illustration, this arrangement does not affect the branch circuit conductor or fuse ratings.

All motors fused: Units are also wired with fuse blocks for all motors. Main fuses no longer are subject to restrictions by motor starters and are sized as feeder protection per Sec. 4362.

It is likely that an arrangement such as this may result in double blowing of the compressor and main fuses if the differential is too small. The use of time-delay fuses in both places will reduce this possibility.

Use of a disconnect switch near the conditioning unit is common procedure; however, units are often located close to main risers or busway feeders, so that fused disconnects may serve as both disconnecting means and short-circuit protection.

Three branch circuits: This method, though probably more expensive, is highly desirable, since branch circuit protective devices are external to the unit and each motor is independent of the others.

Branch circuit wiring in this case is done by the contractor rather than the manufacturer, although equipment diagrams normally specify wire sizes to be used.

Circuit breakers as disconnects: The above refers exclusively to fused disconnects and fused switches. However, Sec. 4402 recognizes the circuit breaker also as a disconnecting means; hence fused disconnects and fuse panels referred to above could also have been circuit breakers or circuit-breaker panels except that literal interpretation of Sec. 4343-b-3 permits only fuses as protection for more than one motor on the same branch circuit.

The diagram illustrating use of circuit breakers includes, in addition to the branch-circuit panel, a feeder panel for distribution to other units. The breakers in the branch-circuit panel serve as branch circuit protection as well as the disconnecting means, and their relative rating is computed per Sec. 4342 and Tables 26 or 27, Chapter 10, using motor nameplate currents (Sec. 4403-b). Tables 20 to 25 would not be involved, since breakers are not rated in horsepower. To satisfy Sec. 4406, the breakers would have to disconnect the unit from all ungrounded conductors.

The sub-feeder between panelboards is sized per Sec. 4314; breakers in this panel are rated using Sec. 4362. The tap from the main riser to the sub-feeder panel need not be protected at the riser provided that the provisions of Sec. 2434-c are fulfilled. That is, the tap must not be over 10 ft long, it must be enclosed in raceway, and its carrying capacity must be not less than the sum of the sub-feeder capacities.

If an additional breaker were installed at the riser, it would be sized in accordance with Sec. 4362. The conductors between this breaker and the sub-feeder panel would no longer have to meet the requirements of the 10-ft tap rule (Sec. 2434c); hence their size would be computed per Sec. 4314, permitting a smaller conductor than that necessary without the breaker.

Protection of control circuits: Control circuits in packaged units may operate at the same voltage as the unit's motors or at a lower voltage, obtained through the use of a control transformer. It is normal to find units with 220-volt motors using a 220-volt control circuit, the control circuit receiving its supply from the line terminals of the motor starter. However, 440-volt units usually incorporate a 440/220-volt or 440/110-volt transformer to obtain the lower voltage control.

The usual control circuit consists of a series circuit connecting all devices which function to start or stop the unit, such as contactor coils, overload heaters, thermostats and pressure cutouts. Units employing more than one compressor motor may connect two such control circuits in parallel.

A transformer mounted within the air conditioner enclosure does not require overcurrent protection as specified in Art. 450, since "dry-type transformers which constitute a component part of other apparatus and which conform to the requirements for such apparatus" are excepted from the provisions of Art. 450 (Sec. 4501).

Sec. 2403g specifies that remote-control conductors must be protected according to their current-carrying capacity, except that they may be considered to be properly protected if the rating of the protective device is not more than 500% of the carrying capacity of the conductors. However, this requirement is superseded by Sec. 4372 if (1) the branch circuit overcurrent device is not more than 500% the carrying capacity of the control circuit conductors and (2) the control circuit does not extend beyond the conditioning unit.

All ungrounded conductors of the control circuit must be disconnected from the source of supply either by the disconnecting means of the circuit by which it is fed or by a separate disconnecting means (Sec. 4374).

Thus, where control devices and transformer are located entirely within the conditioner, no separate fuses need be installed for the control circuit as long as the wire used has a carrying capacity equal to at least 20% of the branch circuit fuse rating. Where this requirement is not met, fuses could be avoided in the control circuit by increasing the size of the control conductors.

Where an externally located thermostat is used, however, separate protection must be provided for the control conductors per Sec. 2403g.

In many cases it is desirable to provide such protection in the control transformer primary rather than in the secondary and size the fuses so that they also protect the transformer. Assuming a 2:1 ratio of primary to secondary voltage, a 15-amp capacity control conductor in the secondary would appear as 7½ amps in the primary, hence primary fuses would be limited to a maximum of 7½ x 5 or 37½ amps. To provide suitable transformer protection, however, the required rating would probably be a great deal less than 37½ amps.

Room Air Conditioners

The provisions of Sec. 4293 were intended to clarify the application of room air conditioners connected to lighting and appliance circuits. Sec. 4293-2 permits air conditioning units to be plugged into *existing* circuits which supply lighting loads or other appliances. By the provision of this section, such a conditioner must not draw more than 7½ amps full load (nameplate rating) when connected to a 15-amp, No. 14 circuit; nor more than 10 amps when connected to a 20-amp, No. 12 circuit. In addition, the *existing* load on the circuit (lights or other appliances) must be low enough so that the total load on the circuit after the addition of the air conditioner is not more than 12 amps on a 15-amp circuit, nor more than 16 amps on a 20-amp circuit.

Assuming that a 7½-amp conditioner is connected to such a 15-amp existing circuit, it would mean that the circuit before the addition of the air conditioner could have been loaded to no more than 4½ amps. At 115 volts, this would mean 517.5 watts. It is unusual indeed to find existing circuits so lightly loaded; consequently the provisions of Sec. 4293 have been widely abused in this respect.

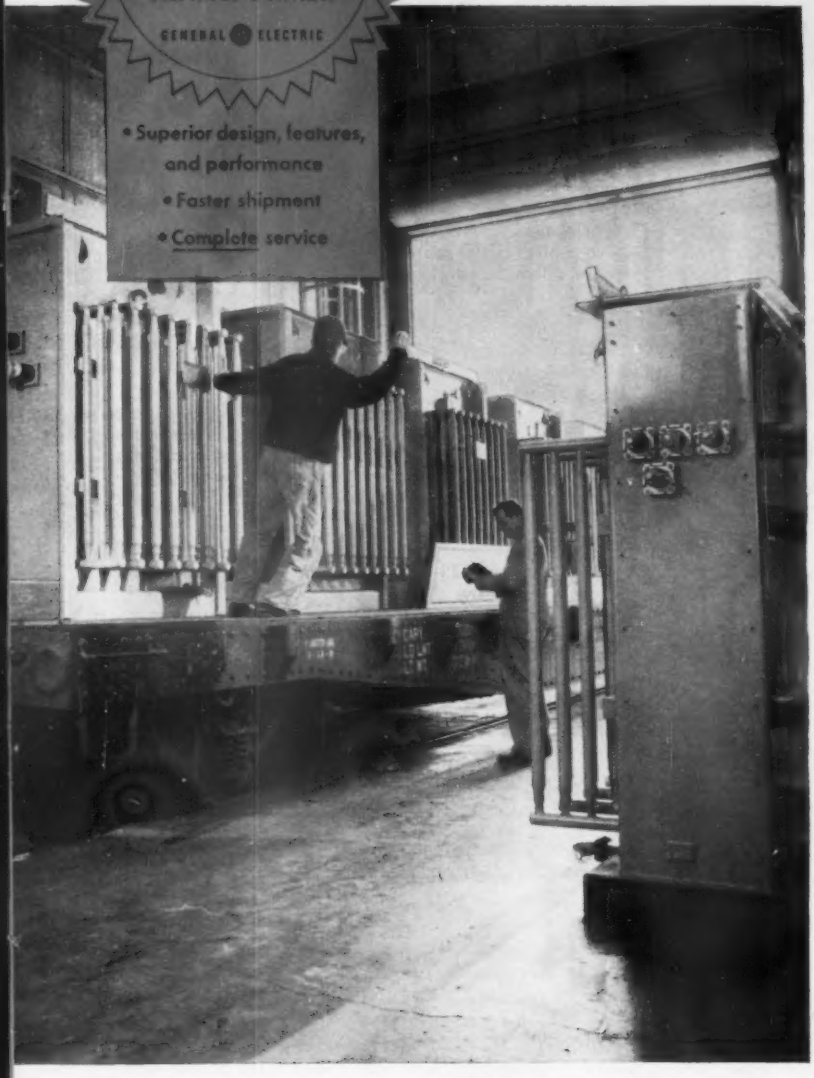
Relative to these provisions is the problem of connecting two or more conditioners to the same circuit. Section 4343a restricts the motors to a maximum of 6 amps at 125 volts or less, or 15 amps at 600 volts or less.

Many local codes avoid the complications of connecting conditioners to existing circuits and connecting more than one conditioner to the same circuit by requiring a separate branch circuit for each.

Underwriters' Laboratories has simplified the problem of protecting circuits to room conditioners by the following requirement in its *Standard for*

FULL VALUE FOR YOUR TRANSFORMER DOLLAR

Pyranol* transformers to 500 kva now shipped direct from G-E stock



Time is money: And, here's how General Electric can help you save both. Now, the five most popular G-E Pyranol filled transformers in ratings 112½-500 kva are carried in factory stock. This means that all tests can be completed and the units shipped to you at least four weeks earlier than before possible.

General Electric Distribution Equipment Transformers—both Pyranol and oil-filled—offer industrial users many performance benefits. Available in either the conventional three-legged core construction (300–500 kva) or the space saving "stacker" type (112½–225 kva), these transformers feature low sound levels and improved pressure-relief devices (Pyranol units).

Faster order handling and shipment plus product leadership are key reasons why you get certified **full value** for your transformer dollar with General Electric's full line of transformers for industry**. But be sure to factor in the complete G-E service provided before, during, and after installation. If you examine the **complete package** offered by General Electric, we're confident you'll recognize G-E superiority.

For complete information and application help, see your G-E Apparatus Sales Engineer or Agent today. Or write for descriptive literature to Sect. 417–6, General Electric Company, Schenectady 5, New York.

* Reg. Trade-mark of General Electric Co.

**Medium transformers (501 to 7500 kva), Open dry-type transformers (300 to 7500 kva), Sealed dry-type transformers (300 to 7500 kva), Distribution Equipment Transformers (112½ to 500 kva), Integral Distribution Centers.

Progress Is Our Most Important Product

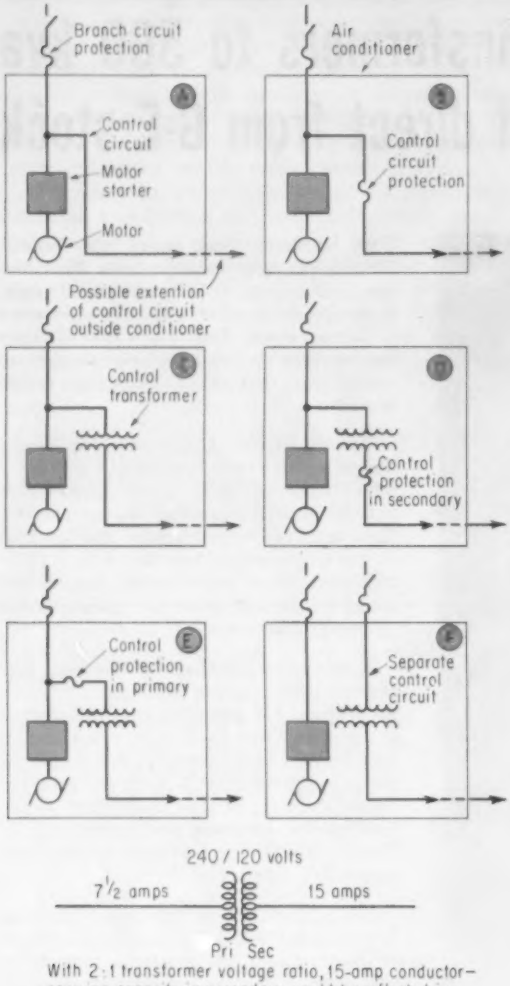
GENERAL ELECTRIC

SUPERIOR DESIGN, FEATURES, AND PERFORMANCE of full-value G-E transformers is typified by new pressure-relief device on Pyranol filled Distribution Equipment Transformers.

FASTER SHIPMENT through rapid processing of orders . . . computer design . . . repetitive manufacture.

COMPLETE SERVICE . . . application engineers . . . installation engineers . . . 50 nearby service shops.

Protection of Control Circuits



With 2:1 transformer voltage ratio, 15-amp conductor-carrying capacity in secondary would be reflected in primary as 7½ amps.

A. Branch circuit protection is not greater than 500% control conductor carrying capacity.
No control circuit protective devices are required, regardless of whether control conductors leave conditioner or not.

B. Branch circuit protection greater than 500% control conductor carrying capacity.
If control conductors do not leave conditioner, no control circuit protection is required. If control conductors leave conditioner, control circuit protection is required with max. rating of 500% control conductor capacity and must not be of time-lag type.

C. Control transformer is furnished with unit; branch circuit protection is not greater than 500% control conductor capacity as reflected in primary.
No control circuit protective devices are required, regardless of whether control conductors leave conditioner or not.

D. Control transformer is furnished with unit; branch circuit protection is greater than 500% control conductor capacity as reflected in primary.
If control conductors do not leave conditioner, no control circuit protection is required. If control conductors leave conditioner, control circuit must be protected in accordance with its current-carrying capacity. Protection may be provided in secondary as shown or in primary as in (E).

E. Where control circuit protection is required as specified in (D), protective device may be placed in primary.
Rating is in accordance with carrying capacity, as reflected in primary.

F. Separate control circuit must be protected according to conductor carrying capacity as reflected in primary, with disconnecting means.

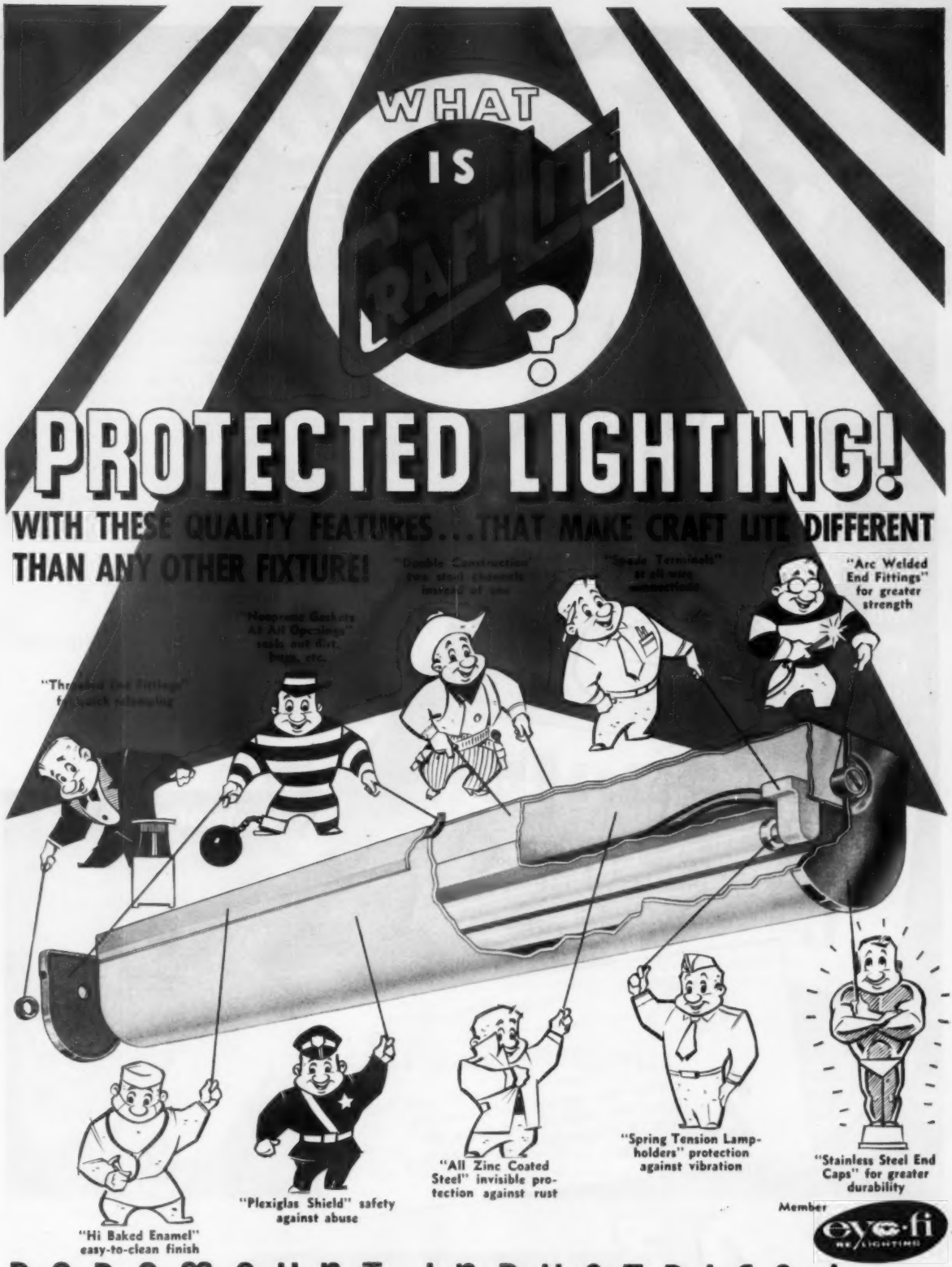
*Room Air Conditioners, UL*484: "A unit which has an attachment plug cap rated not more than 15 amps which will not start and run in series with a 20-amp fuse . . . or a unit which has a 20-amp attachment plug cap which will not start and run in series with a 20-amp fuse . . . shall have a marking on the unit which indicates that time-delay fuses of the proper size are required."

Therefore, it may be assumed that a unit will operate satisfactorily on a standard fuse of the same rating as its attachment plug cap if there is no marking to the contrary on the unit. In any event, a time-delay fuse of the same or smaller rating could be substituted.

If circuit breakers are used for branch circuit protection, a 15-amp breaker will normally hold the starting current if a standard 15-amp fuse will, since such breakers have some inherent time delay. If the unit is marked to require a 15-amp time-delay fuse and a 15-amp breaker will not hold the starting current, few inspectors will object to the use of a 20-amp breaker, since Article 430 permits such a procedure for calculating motor load protection.

Normally, starting problems are not severe with these units, since the low inertia of present-day motor-compressor combinations permits them to reach full speed within a few cycles. Such a rapid drop in starting current is usually well within the time permitted by the trip or rupture characteristics of the breaker or fuse.

Similarly, the question of wire size may be resolved by application of either Art. 210, 420 or 430. Rarely do room conditioners even as large as 2 tons take more than 13 amps running current, hence No. 12 conductors are more than sufficient. In addition, many local codes prohibit use of conductors smaller than No. 12 for air conditioning circuits. In localities where No. 14 wire may be used, the provisions of Sec. 4293-1 restricting the loading to 80% of the circuit rating must determine the wire size, where "rating" is interpreted as referring to the conductor carrying capacity. If Art. 430 is used to determine the wire size, the 125% requirement of Sec. 4312 accomplishes the same result.


WHAT IS CRAFT LITE ?
PROTECTED LIGHTING!
WITH THESE QUALITY FEATURES...THAT MAKE CRAFT LITE DIFFERENT THAN ANY OTHER FIXTURE!
"Arc Welded End Fittings" for greater strength
"Hi Baked Enamel" easy-to-clean finish
"Plexiglas Shield" safety against abuse
"All Zinc Coated Steel" invisible protection against rust
"Spring Tension Lampholders" protection against vibration
"Stainless Steel End Caps" for greater durability

Member eye·fi RE/LIGHTING

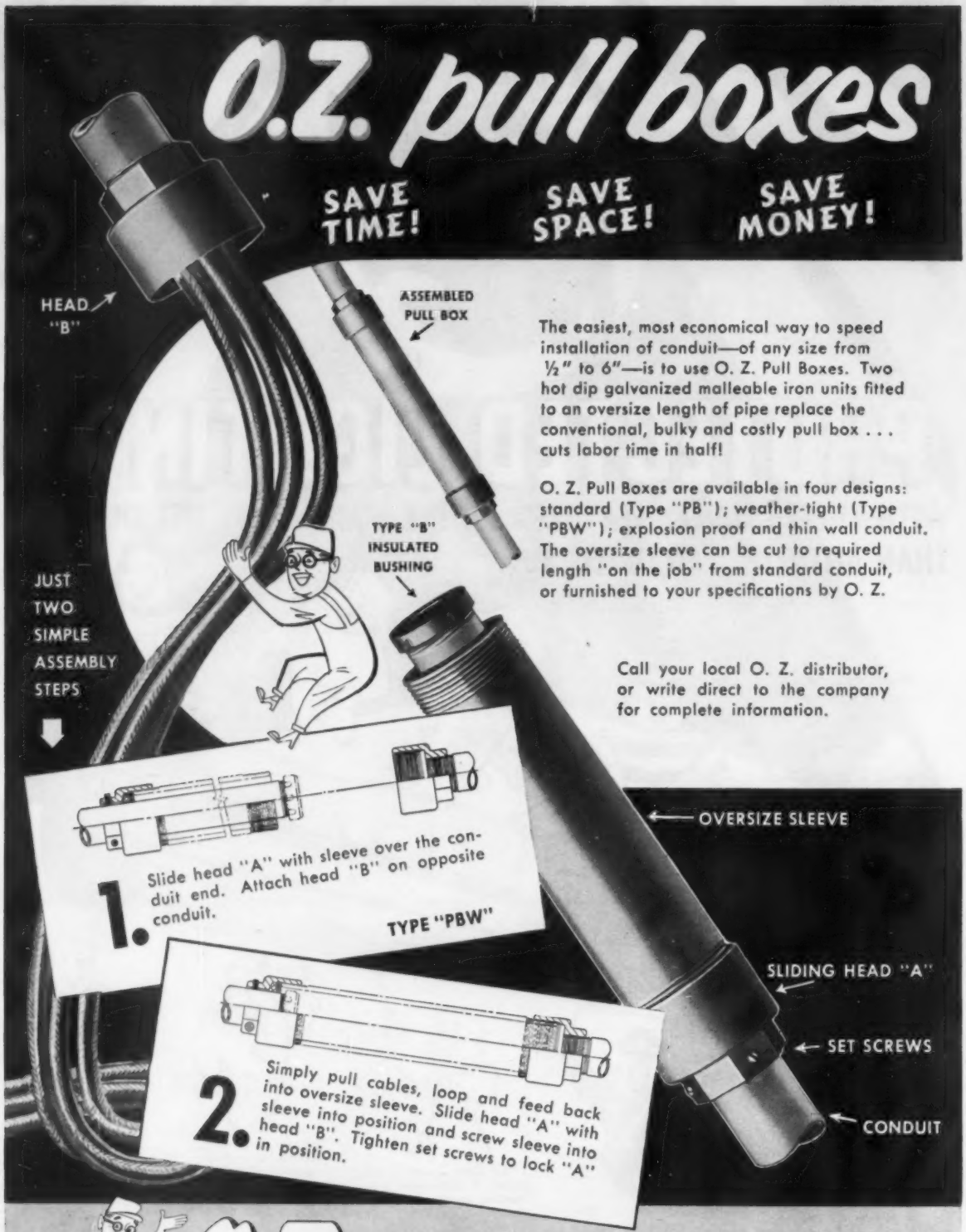
PARAMOUNT INDUSTRIES, Inc.

G-1080 BALLENGER ROAD FLINT 4, MICHIGAN

Manufactured in Canada by C & M PRODUCTS LIMITED, SCARBOROUGH, ONTARIO

O.Z. pull boxes

SAVE TIME! SAVE SPACE! SAVE MONEY!



The easiest, most economical way to speed installation of conduit—of any size from ½" to 6"—is to use O. Z. Pull Boxes. Two hot dip galvanized malleable iron units fitted to an oversize length of pipe replace the conventional, bulky and costly pull box . . . cuts labor time in half!

O. Z. Pull Boxes are available in four designs: standard (Type "PB"); weather-tight (Type "PBW"); explosion proof and thin wall conduit. The oversize sleeve can be cut to required length "on the job" from standard conduit, or furnished to your specifications by O. Z.

Call your local O. Z. distributor, or write direct to the company for complete information.

1. Slide head "A" with sleeve over the conduit end. Attach head "B" on opposite conduit.

TYPE "PBW"

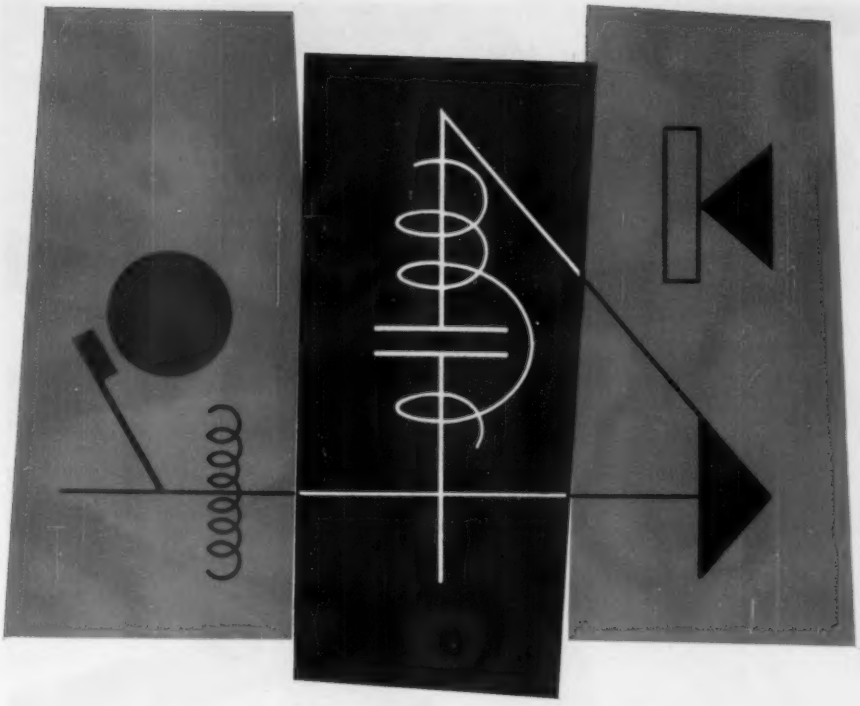
2. Simply pull cables, loop and feed back into oversize sleeve. Slide head "A" with sleeve into position and screw sleeve into head "B". Tighten set screws to lock "A" in position.

O.Z. ELECTRICAL MANUFACTURING CO., INC.

262 BOND STREET • BROOKLYN 17, N. Y.

Sales Office and Warehouse: 406 So. Cicero Avenue, Chicago 44, Ill. • ESterbrook 9-0326
Office and Factory: 749 Bryant Street, San Francisco 7, Calif. • GArfield 1-7846

CAST IRON BOXES
CABLE TERMINATORS
POWER CONNECTORS
SOLDERLESS CONNECTORS
GROUNDING DEVICES
CONDUIT FITTINGS



PROVIDE SYSTEMS FOR . . .

SIGNALS AND COMMUNICATION

THIS section covers a wide range of signal and communication systems. The material has been laid out according to types of buildings, presenting selection and application data on the types of systems used in each type of building.

For any particular application of signal and/or communication systems, design details are closely related to the types of systems and manufacturers' instructions. The many manufacturers of such equipment make available much literature and offer engineering services to assist the electrical designer.

The National Electrical Code covers signal and communication systems in Articles 640, 725, 800 and 810.

Industrial Plants

Industrial plants require a variety of signaling and communication systems, some having individual control equipment, and others interconnected or combined at one point to be supervised by the plant superintendent or the guard personnel.

Fire Alarm

Fire alarm systems should be of the closed-circuit supervised type. City and State ordinances should be checked regarding requirements. Generally non-coded systems are limited to small plants, since they only transmit a general alarm and do not indicate the location of the operated station. Coded systems are preferable since each station transmits a distinguishable signal.

Plain code systems are generally acceptable for a single building. Group systems, using coded stations, are preferable where several buildings are involved. In this type of system, when a station is operated in one building, the signal devices in that building sound and in addition certain predetermined bells sound at specified supervisory locations such as in the power house, executive offices, etc.

Stations must be located near stairways and other paths of escape and must be spaced so that no one

Don't Tie Yourself Up In Excess Tape

Save Money with Dutch Brand's new Plastic Electrical Tape in 44-ft. Rolls

Dutch Brand's new 44-ft. roll of Plastic Electrical Tape costs no more per foot than a 66-ft. roll. To you, this means less funds sunk in inventory. It also means you are *not* tied up in excess tape footage that invites waste and pilfering.

Dutch Brand Plastic Electrical Tape is the easy, *better* way to do scores of electrical maintenance jobs. It's thin, strong, flexible . . . provides a dielectric strength of 9,000 volts. Also provides unusual resistance to acids, alkalies, oils, solvents, fungus, bacteria, and gases. Made to highest industry standards. Available in 20'—44'—66' rolls. Order Dutch Brand Plastic Electrical Tape from your supplier today.

WRITE FOR NEW BOOKLET!

Looking for new ideas on tape as a money-and-time-saver? Ask for "Big Four in Electrical Tapes."

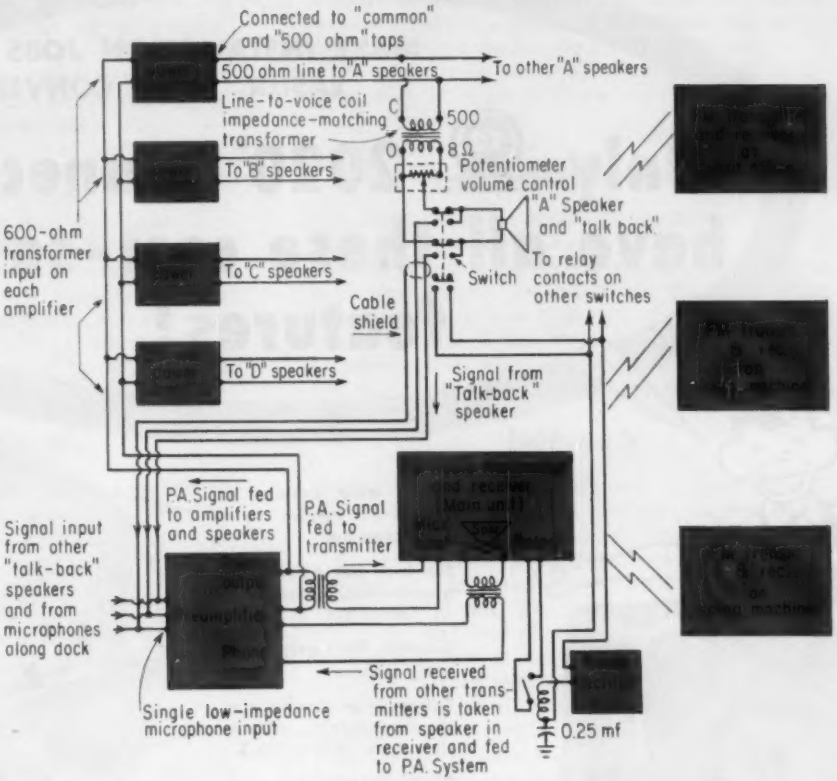
Johns-Manville Dutch Brand Division, 7800 South Woodlawn Avenue Chicago 19, Illinois

JOHNS-MANVILLE JM PRODUCTS

JOHNS-MANVILLE

Intercommunication System of Two-Way P.A. and FM Radio

This system provides rapid and reliable intercommunication between widespread offices and two large mobile icing machines on a long dock used for filling refrigerated railway cars with ice. A wired 2-way sound system is used along the length of the 3300-ft dock, with loudspeakers which also serve as microphone inputs. Radio intercom was found best for tieing the two mobile machines into the system. The amplifiers, preamplifier, main FM unit and other control devices are rack mounted in the main office in the control tower of the yard. Radio communications are received at the main office and reproduced through the P.A. system to all the speakers along the dock. Each speaker can also be used as a microphone to talk to the entire system. Relay unit shown puts main FM unit into transmitting operation when "talk back" switch is used at any speaker location.


Connected to "common" and "500 ohm" taps
500 ohm line to "A" speakers
To other "A" speakers
Line-to-voice coil impedance-matching transformer
500
0
8 Ω
To "B" speakers
Potentiometer volume control
"A" Speaker and "talk back"
600-ohm transformer input on each amplifier
To "C" speakers
Switch
To relay contacts on other switches
Cable shield
To "D" speakers
Signal from "Talk-back" speaker
P.A. Signal fed to amplifiers and speakers
P.A. Signal fed to transmitter
Signal input from other "talk-back" speakers and from microphones along dock
Signal received from other transmitters is taken from speaker in receiver and fed to P.A. System
Single low-impedance microphone input
0.25 mf

need walk more than 100 ft to one. Audible signals such as bells, usually 10 ins. in diameter, or horns of the grille or projector type are distributed throughout the areas so that they may be heard by all persons. An audible signal such as a small bell should be located in the guard room together with a punch recorder and take-up reel and a time stamp for a permanent record of each alarm.

The maximum number of bells or chimes which may be connected on a circuit operating on alternating current is ten. Systems may be provided for the connection of an interior fire alarm to a municipal system.

Automatic fire detection systems may be used separately or combined with the manual fire alarm systems. They should be used in large or small areas such as storerooms, warehouses, boiler rooms and in ducts. Those mounted in ducts may be arranged to disconnect motor-driven blowers and to close dampers in sections of the ducts to prevent further spread of the hazard.

When combined with manual fire alarm systems of the coded type, automatic fire alarm systems may be interconnected by using electrically tripped transmitters. In this way a separate and distinguishable signal may be given for these protected areas.

Watchman's Systems

Watchman's supervisory systems should be of a type which will require the watchmen on the various tours to produce a record in the superintendent's or chief guard's quarters at the start and at the finish of each tour. It should also contain provisions for the calls to be made to each station and in sequence. Extra features may be included in these systems, such as a delinquency indicator which will signal the chief guard when a watchman is delayed in arriving on time at a station. Or a telephone jack and a pilot lamp at each station may be provided so that communication may be had between headquarters and the outlying points. The telephone jack is used for plugging in a handphone which is equipped with cord and plug, while the lamp is used to notify the watchman along the tour that he is to call the central point. All tour stations must be located at remote points to insure complete coverage of the premises.

Sprinkler Systems

These alarm systems are used to signal when sprinkler heads open, when noticeable leaks occur, when waterflow valves operate in either dry or wet systems, when post indicator valves operate or are left open or when the shut-off valves are placed in a sub-normal position. All of these valves are equipped with contacts so that an alarm will be transmitted to either audible signals, annunciators or a combination of same. A supervisory control panel or an annunciator should be provided.

A coded signal may be transmitted to the signal devices of a coded fire alarm system by interconnecting the sprinkler system wiring through an electrically tripped transmitter. These transmitters should be connected to separate supervised circuits on the fire alarm control panel.

MAKE INSTALLATION JOBS
EASIER, MORE CONVENIENT...

Only T&B ENGINEERED 2020* connectors have all these cost-saving features!

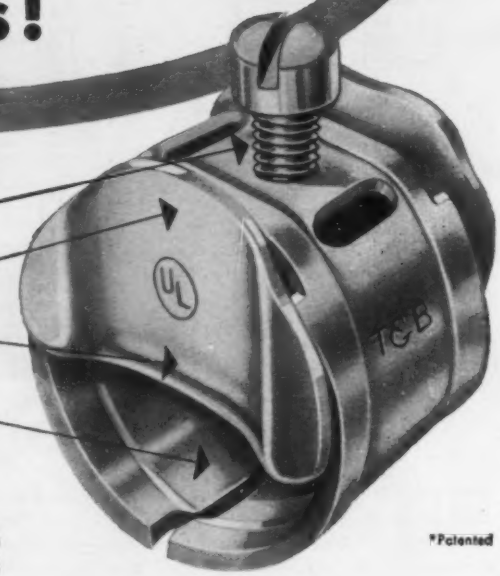
Only one screw to tighten . . . captive so it can't come out

No lock-nut needed — grooves hold connector in ½" knock-out

Smooth, firm grip on all cable sheaths

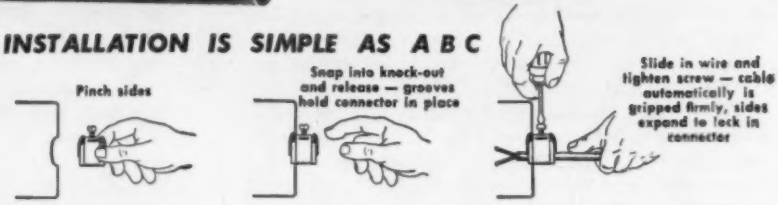
Takes 2- or 3-wire non-sheathed metallic cable in sizes from 14-2 to 10-3

Easily installs from outside or inside box



*Patented

INSTALLATION IS SIMPLE AS A B C


Pinch sides
Snap into knock-out and release — grooves hold connector in place
Slide in wire and tighten screw — cable automatically is gripped firmly, sides expand to lock in connector

T & B 2020's are steel snap-in type connectors for non-metallic sheathed cable. With an easy squeeze, the "2020" snaps into a ½" knock-out and is held fast by grooves. Because this connector installs from either inside or outside the junction box, it is especially good for work on old buildings where damage to walls and floors can be avoided by working from inside the box.

T & B 2020 Connectors have full Underwriter's Laboratories approval. They hold any non-metallic sheathed cable sizes 14-2 to 10-3; 2- or 3-wire cables, also portable cords, etc. – work especially well on currently popular small dimension plastic sheathed cables. Write for samples and descriptive literature.

LOOK FOR THIS SIGN — T&B ENGINEERED IT'S THE MARK OF AN AUTHORIZED **T & B** DISTRIBUTOR

The complete line of T & B fittings for conductors and raceways is sold only by recognized electrical wholesalers. It's our way of assuring you the service and savings of a friendly local source. Call him for all your electrical needs. T-510

THE THOMAS & BETTS CO.

INCORPORATED

34 Butler Street • Elizabeth 1, New Jersey

Thomas & Betts Ltd., Montreal, P.Q., Canada

MANUFACTURERS OF FINE ELECTRICAL FITTINGS SINCE 1898

Smoke Detection

These systems are used to detect smoke in ventilating, air-conditioning and dust-collecting ducts. It may also provide for disconnecting the air blower motor, and to close dampers in various sections of the duct system to prevent spreading of fire.

This is accomplished by means of photo-electric systems wherein the light source directs a beam to a photo-electric cell across the interior of the ducts. The photo-electric equipment may be adjusted to operate when the smoke in the ducts reaches a pre-determined density. The control equipment transmits the signal to annunciators together with an audible alarm at the guard's quarters, and may also be interconnected with the manual fire alarm system.

Thermostatic detectors may be installed in the ducts to indicate abnormal rise in temperature.

Burglar Alarms

Burglar alarm systems may be used to protect all doors, windows, elevator openings, skylights, etc. This is accomplished by the use of various types of spring contact, switches, foil tape and networks of wired lattice-work. Photo-electric equipment may be used to protect stockrooms, toolrooms, filerooms and loading platforms. Safes and cabinets may be protected by special electrified enclosures or capacity alarms. All signals should terminate in a control cabinet at the chief guard's quarters.

Door Alarms

Such systems are used to signal the guard room when certain restricted areas have been entered or vacated by individuals. The doors are provided with contacts which operate lamps or drops in annunciators. An audible signal such as a bell or buzzer is provided at the supervisory location with isolating switches for each circuit. In addition it is desirable to operate a large bell adjacent to each door.

Other Alarms

Hold-up alarms may be used in the disbursing office using special pushbuttons, foot and knee contactors at desks and counters.

Transformer supervisory alarm systems may be used to designate a dangerous increase in the temperature and pressure in oil-cooled transformers. Temperature and pressure switches are provided for this purpose and are inserted into the transformers. Provision may also be made for the release of CO_2 tanks in the transformer vaults.

Paging

Paging systems are used to call and locate individuals for answering telephones, attending meetings, etc. In general these systems may be either of the coded, sound or visual type.

The coded type consists of a code transmitter with audible signals such as bells, horns, chimes or mild-toned sounders and the associated controls.

A sound system consists of one or more microphones, a number of loud-speakers and the associated amplifier equipment.

The visual system used in laboratories and offices consists of a keyboard, lamp annunciators and the necessary control equipment for flashing the lamps and operating a buzzer signal when desired.

Code signals are assigned to the personnel in the coded system. Code numbers are assigned in the visual type of system.

Clock and Program Systems

These are used for indicating the time of day and operating signal devices such as bells or horns at pre-determined times such as starting and stopping work, rest periods, lunch periods, etc. In addition they may also include time stamps, employees' time recorders, elapsed time or job recorders, etc. These systems may be provided with synchronous-motored movements or minute-impulse movements.

Intercom

Intercommunicating telephone systems may be provided in various forms, and the selection should be based upon the practical requirements.

There are cases in small plants where a 2-station or pair of telephones are desired to converse between two points. For larger installations up to about ten stations, where only one conversation is found necessary at one time, the common-talking selective ringing system may be used. In systems requiring a greater number of stations the selective-talking selective-ringing type should be used. Where it is desired to have a small number of telephones supervised from one location, and only one pair of conversations is desired at one time, a master common-talking system is frequently found satisfactory. For large systems the manual switchboard or the automatic dial type systems should be used.

P. A.

Public address sound systems may be used throughout the plant for paging, radio programs, recordings, announcements and entertainment derived from a centralized system. Loudspeakers of the proper type and size are distributed throughout the premises with the wiring to the control center.

Conveyor Signals

Conveyor signal systems are used to indicate to various locations that conveyors are to operate, when they are to stop and when an emergency exists. The system usually consists of pushbuttons which are connected to operate bells or horns. In addition photo-electric units may be installed at various points along the conveyor route with counters to designate the passing of different articles.

Other Systems

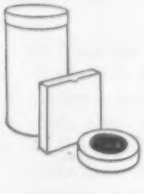
There are many systems which may be used in manufacturing processes. Liquid level indicators supervise the high and low levels of liquid contents in tanks, cisterns, reservoirs. Pressure indicators supervise all measurable forms of pressure such as air, oil, water and steam. Temperature indicator systems supervise liquid and area temperatures.

Tape it easy, Mac!

Gold Seal Tape sticks tight in any weather

You can do a first-class insulating job — easier and faster — with Gold Seal Friction Tape. It tears evenly, conforms readily to uneven surfaces, sticks *tight* in any temperature and under all weather conditions. And one thickness *insulates.* For lasting "tack", for all-around insulation protection, ask for Gold Seal Friction Tape. Made by Jenkins Bros., Rubber Division, 100 Park Avenue, New York 17.

In 10-roll containers or single rolls • Each roll sealed in cellophane, stays fresh



Gold Seal FRICTION • *Rubber • Plastic Tapes...Commercial and Specifications Grades*

Commercial Buildings

Modern office and commercial buildings, whether located in large or small cities are faced with similar basic problems insofar as protection and expediency is concerned.

Fire Systems

Fire alarm systems of the manual type should be installed for the protection of the general public and the employees within the building. Such systems may be of the same type as outlined for industrial buildings.

Fire alarm systems of the automatic type should be installed at all points where records or files are kept or stored. These systems are composed of a quantity of equally distributed thermostatic detectors grouped into zones and wired to annunciator control boards, or combined with the manual fire alarm system through electrically tripped transmitters.

Fire-line signal systems are similar to standard coded fire alarms of the closed-circuit type with the addition of manually operated signal stations which are installed on alternate floors of tall buildings. These manual stations have hinged doors, are equipped with special cylinder locks, and are composed of closed-circuit strap keys which are used exclusively by members of the fire department to transmit signals to the pump room.

The coded and the manual stations are all connected in series. The bells are of the single stroke type and are located in the pump room, elevator shafts and at all points required by the local fire prevention authorities. This feature may also be added to pre-signal fire alarm systems in which case the initial operation of the pre-signal station transmits the coded signals on the fire line or pilot bells. The second operation of the pull lever in conjunction with the insertion of a special plug or key in the station will operate the general alarm on all bells.

Fire-line telephone systems are composed of a master station telephone located in the pump room, sub-master station telephones located in the auxiliary pump room and at the building entrance, and outlying telephones located on each of the other floors. These systems are of the common-talking type.

The master and the sub-master telephones are provided with pushbuttons to selectively call each other. The master station is also provided with a loudspeaker type receiver mounted into the instrument housing. A handset with a long extension cord is included which will enable the operator of the pump to remain at his post. Vibrating bells of 6-in. size are used as audible signals on these telephones. The outlying telephones are provided with pushbuttons for selectively calling the master and the sub-master telephones.

Watchman's Tour Systems

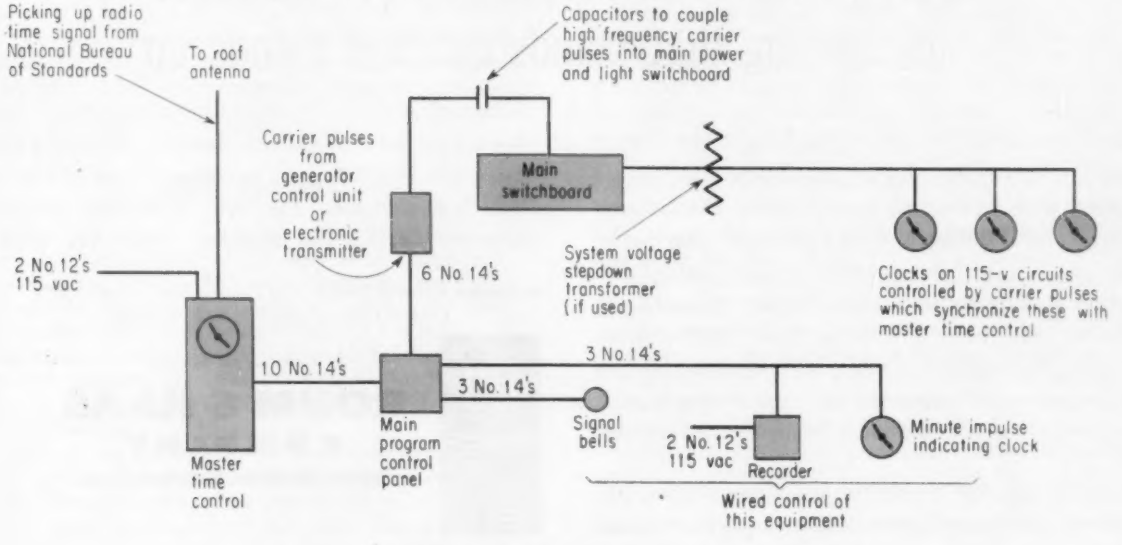
These are considered very necessary. Where the building is part of an industrial group the signals may terminate in the guard's quarters. Where the building is separate, the signals should terminate in the superintendent's office. In general the system may be of the same type outlined under industrial buildings.

Other Systems

Sprinkler alarm systems are also used. However, in office buildings these systems are usually installed in storage spaces and other hazardous locations where a deluge is found necessary to prevent the spread of a fire. It is not usually considered where water might completely damage the contents in a given location.

Smoke detection systems may be used in the various duct systems in ventilating and air-condi-

Simple Wiring Scheme of Electronic and Wired Control System for Clocks


Picking up radio time signal from National Bureau of Standards
To roof antenna
Capacitors to couple high frequency carrier pulses into main power and light switchboard
Carrier pulses from generator control unit or electronic transmitter
Main switchboard
2 No. 12's 115 vac
6 No. 14's
System voltage stepdown transformer (if used)
Clocks on 115-v circuits controlled by carrier pulses which synchronize these with master time control
10 No. 14's
3 No. 14's
3 No. 14's
Master time control
Main program control panel
Signal bells
2 No. 12's 115 vac
Recorder
Minute impulse indicating clock
Wired control of this equipment

PLEXIGLAS

...for lighting that stands out and stands up!

Good interior design includes lighting of the highest quality. That is why so many handsome interiors are lighted with equipment incorporating PLEXIGLAS® acrylic plastic diffusers. With PLEXIGLAS, you can be sure of clean, pleasing appearance, and highest efficiency in transmission and diffusion of light. In addition, the high quality of your lighting *lasts*, because PLEXIGLAS stays free from discoloration on long exposure to fluorescent light, resists breakage, is a rigid material with a smooth, easily cleaned surface.

We will be pleased to send you the names of manufacturers of lighting equipment that includes PLEXIGLAS.

Shown above are 3-ft.-diameter domed diffusers of white translucent PLEXIGLAS, *at conference room of Cluett, Peabody & Company, Inc., New York City. Interior design by Designs For Business, Inc., New York.*

In Canada: *Rohm & Haas Co. of Canada, Ltd., West Hill*
Crystal Glass & Plastics, Ltd., Toronto.

Chemicals for Industry

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

tioning the building and may be applied as outlined under industrial buildings.

Protective alarms are provided in numerous forms to protect doors, windows, floors, ceilings, etc. from intrusion.

Call systems are widely used and are of many types. Individual return-call systems, in which pushbuttons and a buzzer may be combined in one block for calling back and forth, are used between two points. Other systems may be composed of pushbutton blocks on desks, counters, etc., which will operate lamps or drops in annunciators, and pilot or return signals such as lamps on the originating calling station.

Electric door locks are used on doors to be supervised, with operation from pushbuttons at specified locations. Electric door closers may be used and operated from pushbuttons where executives desire to close the doors for privacy.

Clock and program systems may be used in an entire building if occupied by one concern, or by the tenants occupying individual floors.

Garage ramp systems are composed of photoelectric equipment and arranged so that the doors will automatically open to permit an automobile or other vehicle to enter. A double ray is used so that the beams will not be affected or interrupted by a person who may be passing. A diagonal ray may also be used to prevent the door from lowering while the vehicle is still in the ramp. A bell signal may be located in the garage to advise attendants that a vehicle is to enter.

Intercommunicating telephone systems will permit contact with various departments without causing confusion, interruptions or tying up the regular public telephones. These may be secured in different types: either the amplified or non-amplified, master selective-ringing common-talking, selective-ringing common-talking, selective-ringing selective-talking, manual switchboard and automatic dial.

The selection of such telephone systems depends upon the number of stations to be used, whether or not more than one conversation will be held at one time, whether the system is to be under the control and supervision of an individual or whether selectivity is to be obtained without the supervision of an attendant. Other features such as conference calls are also obtainable.

Elevator signals are most important for both passenger and freight elevators. These consist chiefly of "up" and "down" pushbuttons on every floor except on the extreme lower and upper floors, with associated annunciators in the elevator cabs.

All passenger elevators should be equipped with telephones for emergency purposes so that a conversation may be had with the starter on the main floor or the superintendent of the building. A dispatch signal system should also be included for starting the elevators and for signaling at points along the route.

Door signals are usually used between the front, rear and boiler room entrances, to such locations as the main lobby, elevator shafts, superintendent's office and boiler room. All exterior pushbuttons should be of the watertight type. All bells should be of the heavy-duty type.

Schools

Safety is the prime consideration as schools are occupied in many cases by children of all ages. High schools, vocational schools and colleges, although occupied by students of a mature age, are equally in need of efficient and reliable protective systems, as such buildings are very large. In the case of many colleges, they are located in small towns where fire fighting apparatus is not always adequate.

In general there are several types of systems used in schools: manual fire alarm, automatic fire alarm, sprinkler alarm, clock, program, telephones, sound and radio distribution, lecture call, orchestra call and door call.

Fire Alarms

Any fire signal should be distinctive from all other signals, and should be audible to everyone in the building. The apparatus for sounding the alarm should be generously distributed within the path of escape, and should be equipped for fire drill purposes. So-called fire-proof or fire-resistant buildings do not decrease the need for properly drilled students. Even a small fire may fill the corridors with smoke and may result in a panic.

Fire alarm systems for use in schools are usually of four types, having one common characteristic—they are all closed-circuit electrically supervised.

In small schools, either the non-coded or master coded type is frequently used. In the first system, non-coded break-glass stations operate vibrating bells or horns continuously. In the second system, non-coded break-glass stations operate an electrically tripped master movement on the control panel which in turn operates either single-stroke bells or horns, sounding a common coded signal such as 4-4.

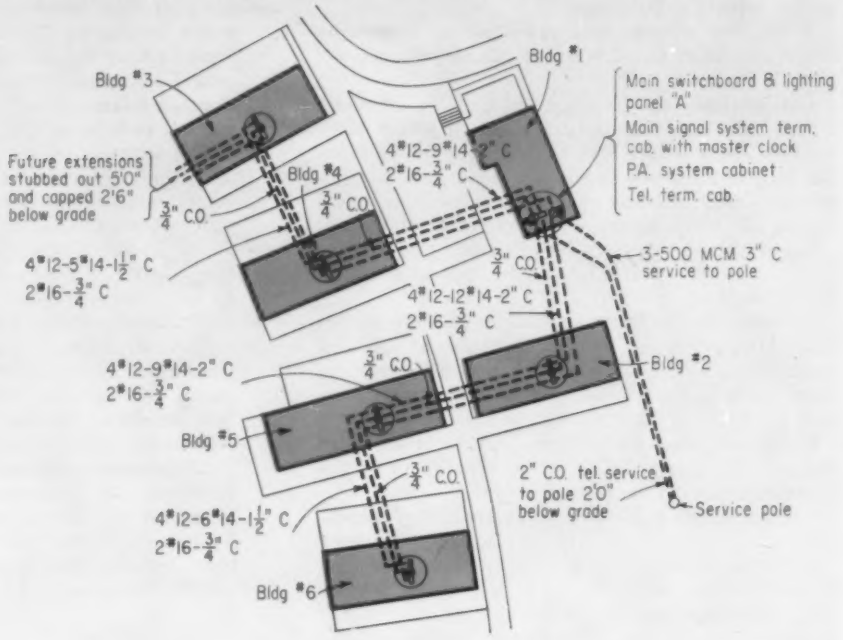
In large schools and colleges, the coded types of system are used wherein every station transmits its own distinctive code to the sounding devices. Where a number of buildings are involved, the coded type systems may be modified and extended to a group system, wherein a fire in one building need not disturb students in other buildings. The operation, therefore, of a station in one building sounds all signals in the same building and only operates signals at certain other locations where supervisors and other members of the staff take command.

Auxiliarized systems, wherein the signal is also transmitted to the municipal fire department, may also be provided and is preferred in many communities. The stations used in this auxiliarized system are provided with a special lock which enables a fire drill to be made with assurance that the signal will not be transmitted outside the building.

Automatic fire detection systems may be included and interconnected with any of the manual fire alarm systems mentioned above. The thermostatic detectors are generally located in the boiler room,

Underground Distribution System for Communications in a Multi-Building School

Here, circuits for clock and program system and for public address and intercom system are carried in underground conduit runs from the main building to other buildings in the school group. A ¾-in. conduit is installed for telephone circuits. Feeders for power and light are also carried from building to building in underground conduit. Each building has terminal cabinets for the separate facilities.



kitchen and storerooms. In older schools having attics, this form of protection is very important.

Other Systems

Sprinkler systems may be used in some areas in the school buildings where the fire hazard is considered great, such as in storerooms.

Clock and program systems provide the means of showing correct time throughout the premises, and to denote the different periods in a day's schedule. In grade schools, the programs are generally arranged to operate signals at the start of classes in the morning, morning recess, lunch period, afternoon recess, and afternoon dismissal. In high schools and colleges the changes in class periods and evening classes must also be considered in setting up the ringing schedules. Program instruments are provided for any minute interval over a 24-hour period.

The clock systems are available in different forms or types, namely, minute-impulse master control, synchronous-motored master control, dual synchronous-motored and electronic.

The minute-impulse system consists of a master clock and a number of secondary clocks and is operated on direct current through a rectifier. The master clock sends out electrical impulses every minute and in addition sends out correction impulses each hour to the secondary clocks.

The synchronous-motored master control system consists of a master clock and secondary clocks which are synchronous motored. The master clock corrects the secondary clocks each hour within specified limits.

The dual synchronous-motored system has no master clock as such but instead all clocks have two motors, one to operate the hands in a normal manner and speed, the other to operate at a much faster rate and which in turn is used to advance the clocks to correct time after an interruption in power.

The electronic system consists of a master clock or transmitter and a number of electronic secondary clocks which operate on a specified electrical frequency and are controlled once each hour by the master clock.

Program systems consist chiefly of a program instrument, a selective signal control board and the necessary audible signals such as bells or buzzers. In sound systems, the bells and buzzers are replaced by an oscillator and loudspeakers. The program instrument is composed of a calendar drum or device, a time drum, signal circuit relays, signal control switches, and program-circuit pushbuttons.

In a small system, the audible signals may be controlled directly from the program instrument. In the larger systems where selectivity is required, a signal control board is used having a pushbutton for each signal device and a set of program cross-connecting busbars with plugs, which permit the changing of program circuits.

In systems incorporating telephones with the signal control board, a handphone is added to this board for communication from the main office to the classrooms and other locations having telephones. The pushbuttons on the signal control board are used for ringing the outlying telephones which actually use the program buzzers in the clock cases.

Elapsed-time clocks may be secured to indicate the time taken by various phases of experiments in laboratories, or the elapsed time in sports such as basketball, football, track, swimming, etc. These are connected individually and are not considered a part of the clock systems.

Telephones are used for intercommunication between the principal's office and the main office and

PARANITE WIRE & CABLE
PARANITE
PARASYN 14 TW
PARANITE PARATEMP 14 RHW
500 FT. 3/64 INS. SOLID S.B. ORANGE
PARANITE PARASYN 12 TW
500 FT. 2/64 SOLID BLUE
PARANITE PARATEMP 12 RHW
PARANITE PARASYN 10 TW
500 FT. 2/64 SOLID YELLOW
10 RHW
PARANITE PARASYN 8 TW
500 FT. 3/64 STRANDED BLACK
PARANITE PARATEMP 8 RHW
500 FT. 4/64 INS. STRANDED S.B. WHITE
PARANITE PARAFLEX 14-2 NON-METALLIC SHEATHED CABLE
250 FT. SOLID WITHOUT GROUND
PARANITE PAR-UFLEX 12-2 UF
250 FT. SOLID WITH GROUND
PARANITE PARAFLEX 12-2 NON-METALLIC SHEATHED CABLE
250 FT. SOLID WITH GROUND
PARANITE PAR-UFLEX 10-2 UF
250 FT. SOLID WITHOUT GROUND

THE EASY WAY TO POSITIVE WIRE IDENTIFICATION...

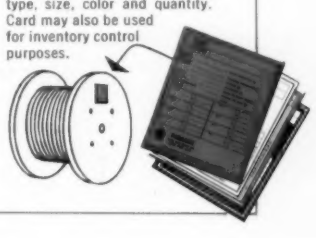
PARANITE® "Color-Coded" LABELS

Size, color and type of wire are all just a "glance" away, thus providing you these proven benefits:

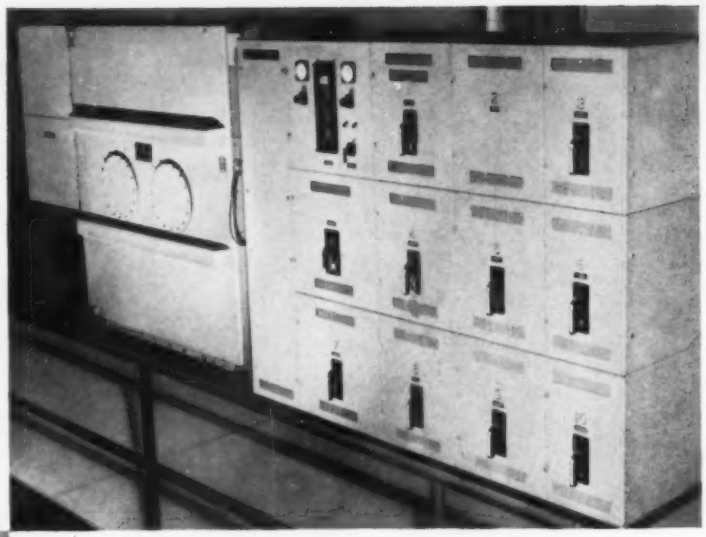
- A Savings of Time and Money.
- Accurate Identification in the Warehouse and on the Job.
- Quick and Error-Free Assembly of Orders.
- Man-Hour Economy.
- Immediate Inventory Control.

TW and RHW are the *same color* as the packaged wire. Non-Metallic Sheathed Cable and UF with ground are identified by *green labels*. *White labels* are used to identify Non-Metallic Sheathed Cable and UF without ground. Quantity and conductor-type are also easy-to-see on PARANITE's "color-coded" labels. Another reason why we say "If It's Paranite It's Right."®

NEW!
PARANITE REEL CARD
for instant identification of wire type, size, color and quantity. Card may also be used for inventory control purposes.



PARANITE WIRE AND CABLE DIVISION
Essex Wire Corporation, Marion, Indiana
MANUFACTURING PLANTS: Marion, Ind.; Jonesboro, Ind.; Tiffin, Ohio; Birmingham, Ala.; Anaheim, Calif.
Sales Offices in all Principal Cities



Wagner

SEALED DRY-TYPE TRANSFORMERS

These modern unit substation transformers can be safely installed in any load-center—any place—because they are hermetically sealed in welded steel cases to provide positive protection from contamination, fire and explosion hazards. The only maintenance needed is periodic checking of gas pressure (inert nitrogen), case and bushings.

Here's Reliable Power

for your plant electrical system

WAGNER LOAD-CENTER TRANSFORMERS

Wagner

INDOOR DRY-TYPE TRANSFORMERS

These new quiet-type transformers are compact, light in weight, provide a flexible, modern power system to change higher voltage distribution service to lower voltage lighting and power circuits. They meet all safety requirements for indoor installation.

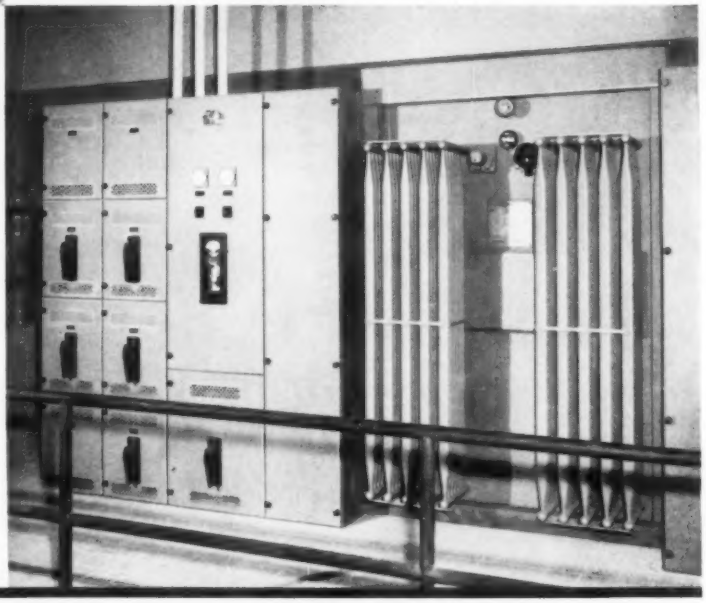
Wagner

NOFLAMOL TRANSFORMERS

Non-inflammable liquid filled. For indoor or outdoor installation. Close-coupled design fits flush against switchgear enclosures, to eliminate and save space. Throat-connected designs are also available.

Bulletins TU-205 and TU-214 give full information on Wagner Load-Center Transformers. Write today.

WT59-2



BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Wagner Electric Corporation

6413 Plymouth Ave., St. Louis 14, Missouri.

SERVING 2 GREAT GROWTH INDUSTRIES . . . ELECTRICAL . . . AUTOMOTIVE

the classrooms. This may be accomplished by means of a master system having a central telephone in which the pushbuttons are used to call the outlying telephones each of which has an audible signal enclosed within the instrument. Or the signal control board of the program system with a handphone and the associated control equipment may be used as the master, using standard outlying telephones with their enclosed signal or outlying telephones without a signal, in which case the program buzzer in the clock cases would be used as a signal.

The classroom telephones are usually of the wall mounted type, while those in the principal's and assistant principal's offices would be of the handphone-on-cradle type. In large high schools and colleges, a manual switchboard system or an automatic dial type system is often used. In the former, the operator would have full control of the traffic between all points. With the automatic type, each person using the system may dial any telephone.

Sound and radio distribution systems are used in all types of schools. These systems consist chiefly of a control desk, microphones and loudspeakers. The control desk is composed of individual control switches for each outlying loudspeaker in classrooms, auditorium, gymnasium, athletic field, etc., together with monitor speaker, microphone, record turntable, radio receiver, amplifiers and other control devices. The microphones are located at the control desk, principal's office and stage with outlets at other points as selected. The loudspeakers are located in the classrooms, auditorium, gymnasium, corridors, cafeteria, athletic field, etc.

The system enables the distribution of radio programs, recordings, lectures and announcements to all points selectively or collectively. If desired, the talk-back feature may be included which will permit conversations to take place between the monitor speaker at the control desk and the loudspeakers in any classroom.

Lecture call systems are in reality return-call systems and are used between the stage in the auditorium and the projection booth. Most of these systems consist of a station on the stage, installed on the wall or in the floor. A long portable cord with a detachable plug and a pendant pushbutton is a part of this station and is used for calling the projection booth where a buzzer is sounded.

A buzzer is mounted on the wall of the stage and is controlled from the station in the projection booth which consists of a pushbutton mounted on the wall, ganged with the buzzer used for calling from the stage. A pilot light may be added to the projection booth station with a switch so that either the buzzer or the pilot light may be operated. Telephones may also be combined in these systems.

Orchestra call systems are usually return-call systems in which lamp annunciators with a buzzer and pushbuttons are used, and these are located in the orchestra pit.

Hospitals

There are several types of systems used in hospitals, namely visual and audio nurse-call, emergency calls, psychopathic alarms, paging, "In" and "Out," sprinkler alarms, intern, ambulance, clinic, inter-phone, nurses' home room-call, clocks, laboratory, fire alarm, watchman's report, elevator and dumbwaiter signals, door-calls and ground detector signals.

Nurse Call

Nurse-call systems are used by the patients to call a nurse or attendant to the bedside. There are two general types of such systems—the visual and the audio. By pressing a portable button, lights are caused to be illuminated over the patient's door in the corridor, duty rooms, diet kitchens and the nurses' stations on a given floor or section thereof. In the case of a ward, a pilot light is included with the calling station or is mounted on the ceiling above the curtained cubicles to ascertain the origin of the call.

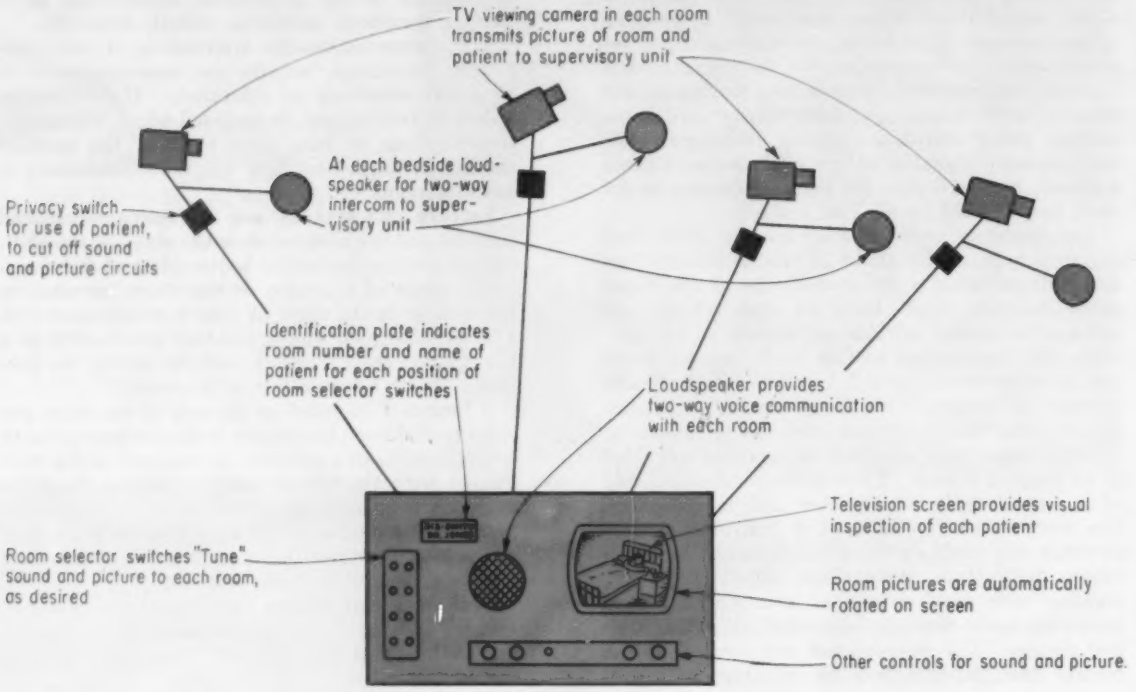
The lamp signal at the nurse's station may be a single common lamp for a floor, or a section thereof, or an annunciator with an indicating lamp for each room. The choice depends upon the number of rooms, shape and size of the floors, the number of nurses available, and the amount of efficiency desired. In addition to the lamp signals, a buzzer is located at each supervisory point such as duty rooms, diet kitchens and nurses' stations together with a cut-off switch permitting full control at all times.

Directional pilots are of assistance when used with nurse-call systems. They are used to direct attention to the nurses while enroute between patients' rooms and points of supervision. They indicate the general direction of a call without having to return to a supervisory point. These signals consist of door-lamp stations mounted on the ceiling of a corridor intersection and may be interconnected with other floors.

Nurse-call stations of the visual and audio type using locking buttons may be ganged with other outlets such as radio, public telephones, duplex convenience receptacles, night lights, etc. A barrier must be provided in the outlet box whenever a lighting circuit enters adjacent to a low-tension outlet. However, nurse-call stations of the visual and audio remote-reset type use momentary-contact buttons.

The audio or voice feature is used in conjunction with the visual nurse-call system and is a valuable adjunct since the nurses may converse with the patient and in that way can give better service and save considerable time and footsteps. In this system, the patient presses the pushbutton in the usual manner and all lights and buzzers operate as previously described. The chief change is at the nurse's station, where in a new installation the annunciator is omitted, since the lamps, the control and the audio equipment is enclosed in one unit. A loudspeaking unit is located in the wall at the head of the bed or on the night table alongside the patient's bed. When the patient presses the button, a lamp illuminates in the master unit at the nurse's station. A control key for that station or room is operated by the nurse and the circuit is completed for talking.

Basic Layout of Audio-Video Nurse-Call and Patient Supervision System


TV viewing camera in each room transmits picture of room and patient to supervisory unit
At each bedside loudspeaker for two-way intercom to supervisory unit
Privacy switch for use of patient, to cut off sound and picture circuits
Identification plate indicates room number and name of patient for each position of room selector switches
Loudspeaker provides two-way voice communication with each room
Television screen provides visual inspection of each patient
Room selector switches "Tune" sound and picture to each room, as desired
Room pictures are automatically rotated on screen
Other controls for sound and picture.

MAIN SUPERVISORY UNIT AT NURSE'S DUTY STATION

All other lights in the corridor and supervisory points remain illuminated until the button is reset at the patient's bedside in the case of locking button systems, or reset at either the patient's bedside or at the nurse's station in the case of the momentary-contact button type.

Emergency Call

An emergency feature may be added to any nurse-call system. This is, in most cases, used by the nurse to call assistance to a patient's room when the occasion requires. In the case of a locking button nurse-call system, the emergency button has the same contact mechanism as the portable button; but it is mounted directly on the gang plate. When this button is operated it illuminates separate and distinct lamps and audible signals. As an example, a red or green lamp is added to each corridor lamp station and to all supervisory stations. In addition a bell, which operates continuously, is used.

Psychopathic alarm systems are used as a protection in the event a nurse or attendant is attacked by a violent patient. Such a system consists of corridor-control stations, room-calling stations, corridor lamps and supervisory stations as for the regular nurse-call system.

When an attendant enters a room, the corridor control station is set by means of a key before going into the room. This immediately energizes the room stations within that room and lights a clear lamp in the corridor indicator and at the supervisory points. Should it become necessary to call for assistance, the room stations are operated by means of a pushbutton which lights colored lamps at all points described previously and operates a bell continuously at the nurse's station and at other points desired. The system is de-energized by resetting the corridor station.

Paging Systems

Paging systems are used to locate doctors and other members of the staff throughout the building. There are three general types of systems used: visual, sound and coded.

The visual system uses lamp annunciators throughout but also incorporates an audible signal such as a buzzer or chime in the event an occasional selective signal is desired. In the visual type, three and as many as six persons may be paged at one time by setting up the combination of code numbers. Usually three-digit figures are used, although occasionally one, two, or four digits are used for other code number combinations.

The sound system consists of loudspeakers throughout the one or more hospital buildings. In the sound system, the name of the person is transmitted through microphone.

The coded system uses bells, buzzers, sounders or chimes throughout the hospital building. In the coded system each person is assigned a code number which is transmitted from a central point to all audible signals.

"In" and "Out" systems are used by the doctors and other members of the staff to designate whether

Not a worry in the world of fluorescent lighting with the new Advance fluorescent lamp ballast service warranty program

ADVANCE FLUORESCENT LAMP BALLAST
SERVICE WARRANTY POLICY

This new ADVANCE Fluorescent Lamp Ballast Service Warranty Program has been designed to protect every fluorescent lighting equipment manufacturer, specifier, supplier, installer and fluorescent lighting user against labor costs arising from an excessive number of failures directly attributed to self-contained components within an ADVANCE Fluorescent Lamp Ballast. Contact your ADVANCE Representative or write for details on this amazing new protection plan.

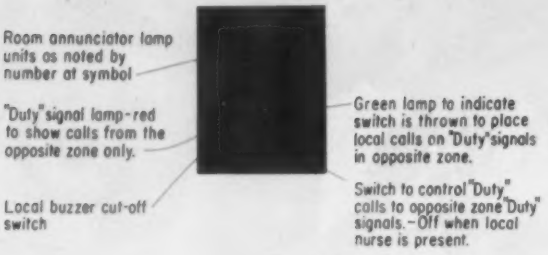
ADVANCE®

TRANSFORMER CO.

World's Largest Exclusive Manufacturer of Fluorescent Lamp Ballasts

2950 NO. WESTERN AVE. CHICAGO 18, ILL. U.S.A.

Sketch of Typical Nurse-Call Annunciator Indicates Functions of Components


Room annunciator lamp units as noted by number at symbol
"Duty" signal lamp - red to show calls from the opposite zone only.
Local buzzer cut-off switch
Green lamp to indicate switch is thrown to place local calls on "Duty" signals in opposite zone.
Switch to control "Duty" calls to opposite zone "Duty" signals. - Off when local nurse is present.

or not they are present in the building. Generally, an entrance register, having a lamp and a switch for each person, is located near the main entrance of the building or in the doctors' cloak or lounge rooms. Another unit known as the office register and having the same capacity is located near the telephone switchboard operator. In the standard type system the office register does not require switches, but in the recall or message type system, a switch adjoins each lamp, the same as for the entrance register.

In the system using the entrance register and the regular office register, the doctor operates the switch alongside his name and thus causes the lamp to illuminate his name at the entrance register and at the office register. When he leaves the building he returns his switch to the original position in order to extinguish the lamps. In the message signal type, the operation of the switch in the office register by the telephone switchboard operator causes the connected lamp to flash in both units and indicate that such a person is wanted at the office to obtain a message, instructions or mail before leaving the building.

Other Systems

Intern-call systems generally consist of either a return-call system or a master telephone system between the interns' living quarters and the head nurse's or superintendent's office. In the return-call system a pushbutton board with a buzzer is located at the central point, and a return-call station consisting of a buzzer and pushbutton is located in each intern's room.

Sprinkler alarm systems are used where it is deemed necessary to deluge the contents of a room to insure against spread of fire from one point to another.

Ambulance calls may be kept separate but are often combined on an annunciator with other door signals. In most cases, however, the system is so arranged that a bell operates with the annunciator indicator as a distinctive signal when a pushbutton is operated from the ambulance entrance.

Clinic systems are generally composed of annunciator or buzzer call systems. In the case of examination and dressing rooms, a pushbutton plate is located in the former having a pushbutton for each dressing room. A buzzer is located in each dressing room. The signal designates that the doctor is waiting for a specific patient.

Interphones are used between the main kitchen and the floor diet kitchens and are usually located near the dumbwaiters. They may also be used between the offices, nurses' stations, supervisors, etc. For the kitchen service, a master system may be used wherein the master telephone may be located in the main kitchen equipped with a pushbutton for each outlying telephone. The outlying telephones are provided with a single pushbutton. In this system the master telephone can call any of the outlying telephones, but the outlying telephones can only call the master. For intercommunication between a small number of offices and various departments, a selective-ringing common-talking system may be used. In larger systems using more than 12 telephones a selective-ringing selective-talking system should be used.

Nurses'-home calling systems are composed of the same equipment as previously described under intern-call system. In very large nurses' homes, the central control unit should be of the plug and jack type wherein a telephone type jack is used for all rooms having the same last two digits in their room numbers.

Clock systems are very important in hospitals, both for keeping time and in administering anesthesia. Clocks are located in offices, corridors, nurses' stations, kitchens, laboratories, operating rooms, lounges, etc. Seconds-beat clocks should be installed in operating and delivery rooms.

Laboratory signal systems are used for various purposes. Contacts may be placed on the doors of cabinets which contain drugs, narcotics, etc., and the signals may be transmitted to an annunciator located in the office of the person in charge. An interlocking door control system may be provided on the doors leading to the darkroom for the development of X-ray films. This is so arranged that no one may enter such a room unless an inner or another entry door is closed to insure that bright light does not enter the developing room.

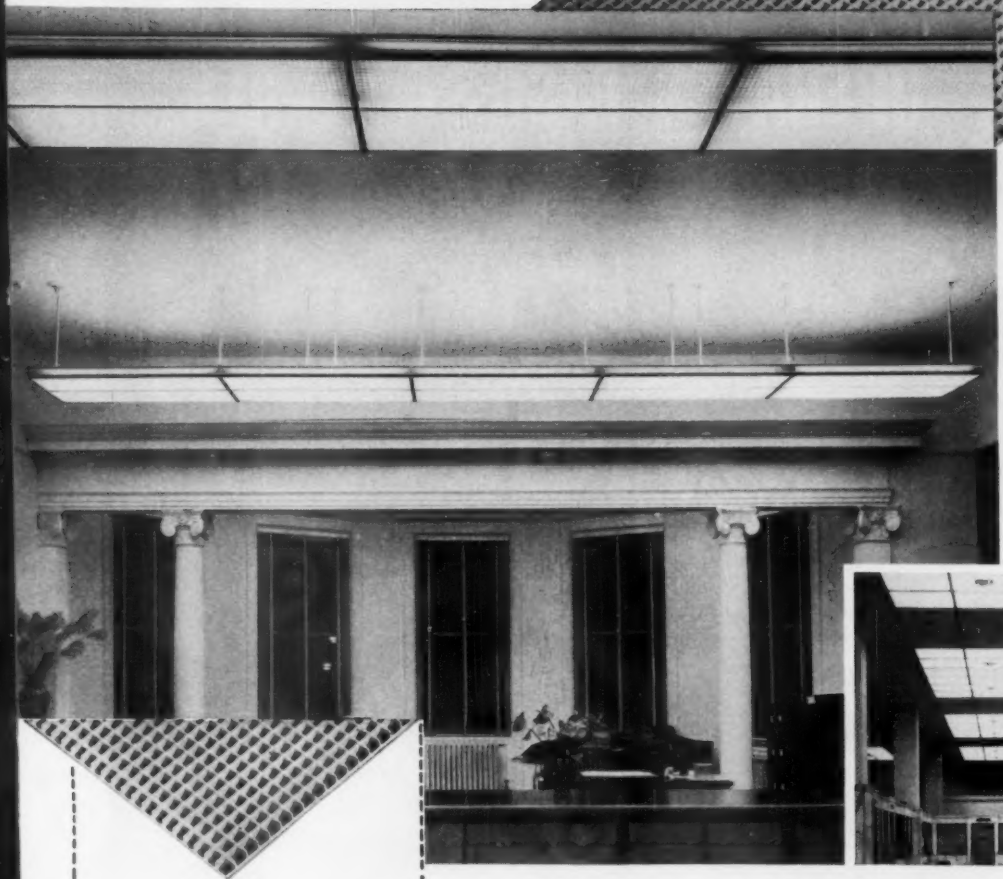
Fire alarm systems for use in hospitals are usually of the pre-signal type. In this type of system the first operation of the pull lever in the coded station only operates pilot bells at certain supervisory points such as the superintendent's office, chief nurse's office, engineer's office, elevator shafts, etc. Upon arrival at the point of the fire, if it is deemed necessary to vacate the building, the officer in charge inserts a plug in the station alarm jack and pulls the lever so that all bells throughout the building operate.

Watchman's report systems are used in hospitals to insure that the premises are covered properly at night. The types of systems described in other sections may be used for this purpose.

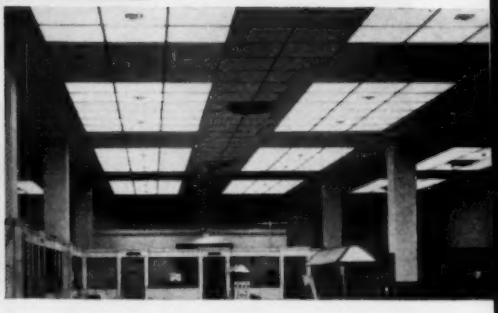
Sound and radio systems enable the patients to listen in on one or more channels of radio programs, recordings, announcements, etc. Connection of the headphone or loudspeaker is made by plugging into the jack on the wall plate, usually ganged with the nurse-call station. Provision should also be made for television, the outlets being located in solariums, day rooms and lounges.

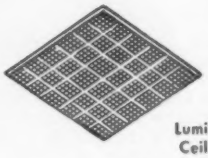
Elevator signals for passenger and freight are always provided, and are usually furnished by the manufacturers of these units. Signals are also required for dumb-waiters.

LEADING FIXTURE MANUFACTURERS *use* american plastic louvers . . .

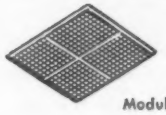


- **Library Office .**
  Lighting by Curtis
- **Gary Bank**
  Lighting by Sweeney Electric Co.



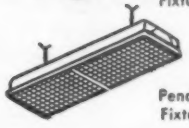


Luminous Ceilings



Modules

Surface Fixtures



Pendant Fixtures

- American Louvers are available in white, and your choice of pastel colors.

Because the exclusive process of American Plastic Louvers provides the finest shielding media for all types of lighting equipment

American Plastic Louvers offer the maximum in conformability for any lighting plan, whether it be commercial, institutional, or industrial. They give soft—glare free, efficient inexpensive visual comfort. Maintenance free—self-aligning for individual fixtures, modular patterns or full ceiling installations.

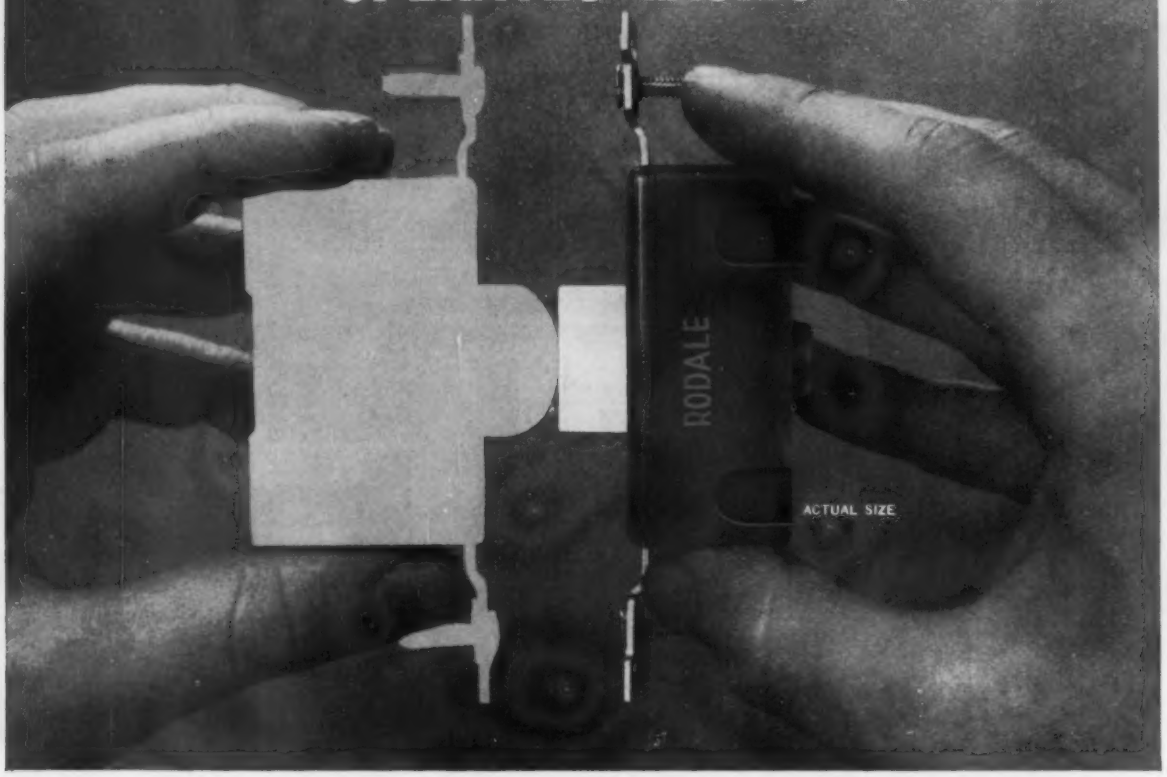
Be sure to specify American Plastic Louvers on your next lighting job for the ultimate in lighting.

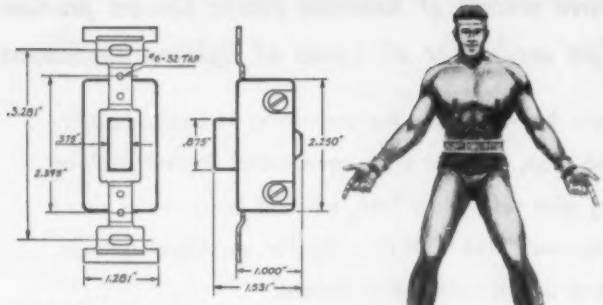
OUR ENGINEERS in your area are available to help you with your lighting problems . . . for additional information, write for detailed bulletin.

an louver compa

Test It Yourself Against Any Touch Switch

Touchette®
OPERATES EASIEST OF ALL





U. S. Pat. No. 2,820,113
other patents pending foreign patents applied for

UL LISTED—CSA APPROVED

In single pole, double pole, 3-way and 4-way models.
Brown or ivory touch button.

Compare Touchette with any touch switch simply by pressing them together, button to button. With just the merest pressure, you'll see Touchette switch on . . . then, with considerably more pressure, the other switch will do the same. It's as easy as that to prove to yourself which switch actuates more easily. For that's the beauty of Touchette. Just a feather-light touch . . . it's on. Another touch, and it's off.

Feature for feature, you'll find Touchette the ideal switch for new construction or remodeling jobs. Easy to handle, Touchette measures *just one inch in depth* . . . is quickly installed even in boxes where several wires already enter. Rated 15A-120-277V, Touchette operates on full line voltage . . . fits standard outlet boxes and toggle wall plates . . . needs no special wiring.

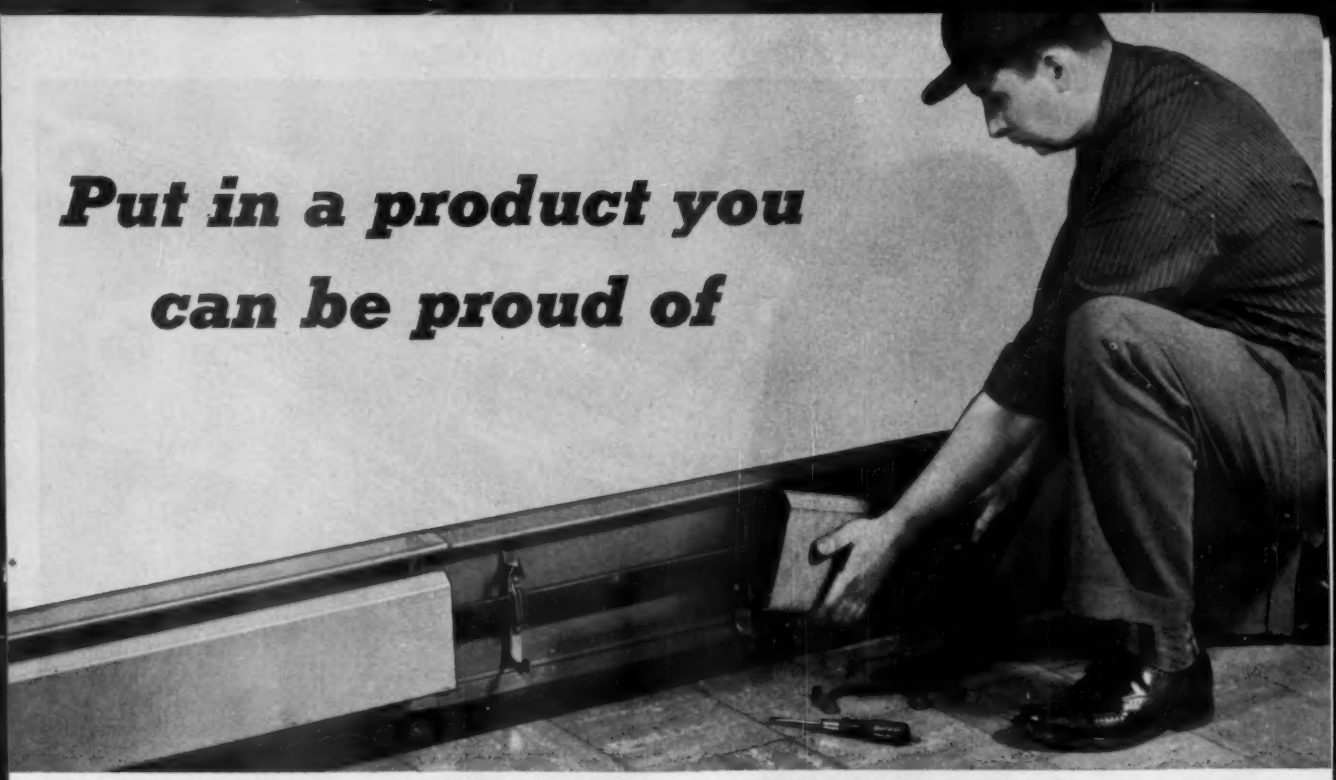
Yet with all these operating and installation "plusses," Touchette is the *least expensive touch switch* on the market.

Could any touch-action switch possibly offer more?

Sold only through electrical wholesalers.
Or for further information and prices,
write Rodale direct.

Rodale / manufacturing co., inc.
dept. C5 emmaus, pa.

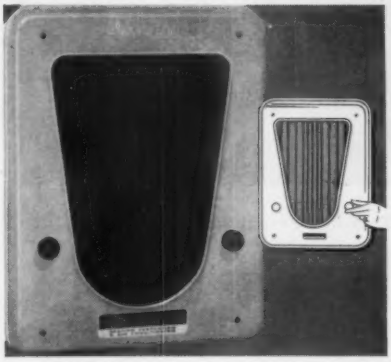
Put in a product you can be proud of



Ilg Radiant Baseboard panels arrive on the job in perfect shape —protected in sturdy, easy-to-carry cartons, sized to the individual lengths you need. Ilg baseboard comes in 2′, 5′, and 8′ lengths, for surface or semi-recessed mounting. Open the carton and you have everything you need for the job—back panel with heating element, front panel, full line of accessories.

Finishing Touch. Ilg radiant baseboards are a "snap" to install. You just (1) screw or nail the back panel complete with heating element to studding, (2) connect power to splice box by bringing in wires from rear, bottom or sides, and (3) snap on cover panel, end covers and corner pieces. Baseboard can be painted to match any room color. No primer needed. Send for Bulletin 1401.

INSTALL ILG ELECTRIC HEAT



Good Things Come in Small Packages. Ilg fan-driven electric wall insert heaters pack tremendous heating output into small space. Three sizes deliver 6824 B.t.u./hr., 10,236 B.t.u./hr., 13,648 B.t.u./hr.. Finned heating elements are sagproof, moistureproof, shockproof. Thermostat is separately controlled by own selector dial—cannot cause radio or TV interference, operates within 55-85° range.

Separate "on-off" switch sets heater in automatic operation without disturbing comfort level of thermostatic setting. Heavy sheet metal case with baked-on sea-foam beige enamel extends only 1½" into room. Send for Bulletin 1101.

Pick Your Capacity. Ilg electric unit heaters range in size from 1½ to 36 kw. All heaters have non-glowing, steel-sheathed, black-heat type replaceable heating elements . . . super-quiet Ilg "Q" type aluminum fan wheel direct-connected to Ilg-built motors. Choice of automatic or manual controls. Capacities from 5118 to 122,832 B.t.u./hr. Complete units bear Ilg famous "One-Name-Plate" guarantee. Send for Bulletin 808.

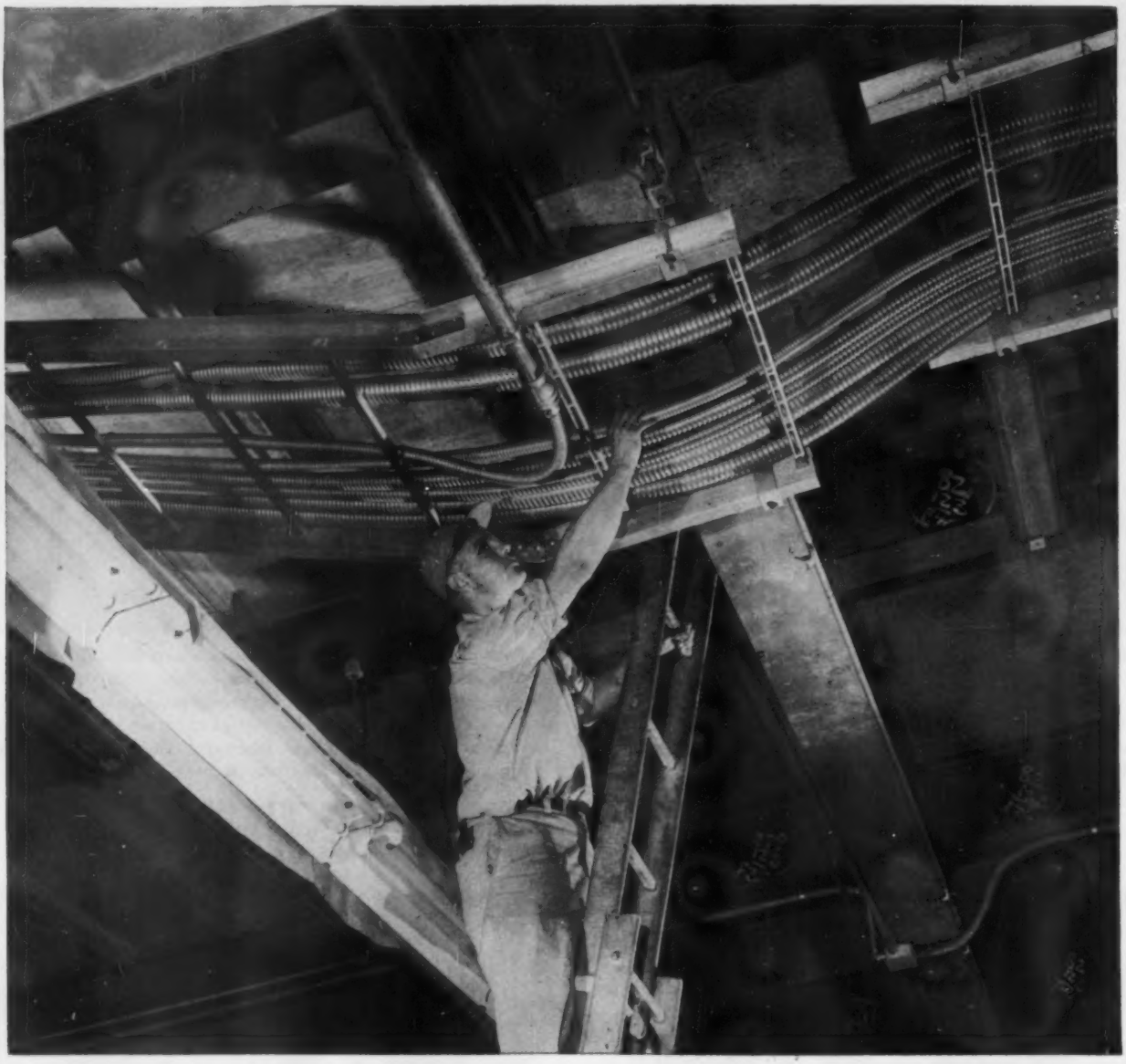
Name Your Mounting. New Ilg electric cabinet heaters have 2- and 3-speed blow-through or draw-through motors; for floor, ceiling, wall or inverted mounting.

Finned strip heating elements. High-limit cutout. Permanent or renewable filters. Manual, pneumatic, or automatic electric controls. Capacities 3.33 to 30.0 k.w. Send for Bulletin 1801.

ILG®

ILG ELECTRIC VENTILATING COMPANY

2879 No. Pulaski Road, Chicago 41, Ill.
Offices in 57 Principal Cities
Member of Air Moving and Conditioning Association Inc. (AMCA)



Armorlokt Cables are easy to install around bends or obstructions, readily accessible for repairs and are available for indoor and outdoor applications.

USS

Tiger Brand Electrical Wire & Cable

A standard cable for every special job

- Asbestos Wire and Cable
- Mold-Cured Portable Cord
- Shovel & Dredge Cable
- Paper & Lead Cable
- Varnished Cambric Cable
- Interlocked Armor Cable
- Special Purpose Wire & Cable
- Aerial, Underground and Submarine Cable

What's the difference in electrical cable?

You can install USS Armorlokt in half the time—at half the cost

Take a close look at the main illustration. With Tiger Brand Armorlokt Interlocked Cable, it's a simple job to run power and light lines around a steel beam. We know, from experience on other jobs, that a conduit system would require about twice as much time to install. It would probably have required larger size cable, because of the higher voltage drop . . . *and it would cost about twice as much!*

Greater current-carrying capacity. For a given conductor size, Armorlokt will have a higher current capacity than three single conductor cables pulled into a steel conduit. As an example, 500 MCM 3-conductor varnished cambric cable with galvanized steel interlocking armor will have a current-carrying capacity of 417 amperes with a copper temperature of 85°C. Three single conductors of the same size in a steel conduit will have a current-carrying capacity of 380 amperes. Putting it another way, 350 MCM Armorlokt might serve, where 500 MCM would otherwise be required in conduit . . . a big saving in favor of Armorlokt.

Less material—less space. With Armorlokt, costly pipe fitting, bending and pull boxes are eliminated. Installation time is cut approximately in half. Space savings as high as 55% to 75% over conduit are common.

Greater layout flexibility. When distribution systems are laid out with easily-accessible, readily-traceable Armorlokt Cables, it is a simple matter to change machinery locations. This might well be a deciding factor in industrial plants.

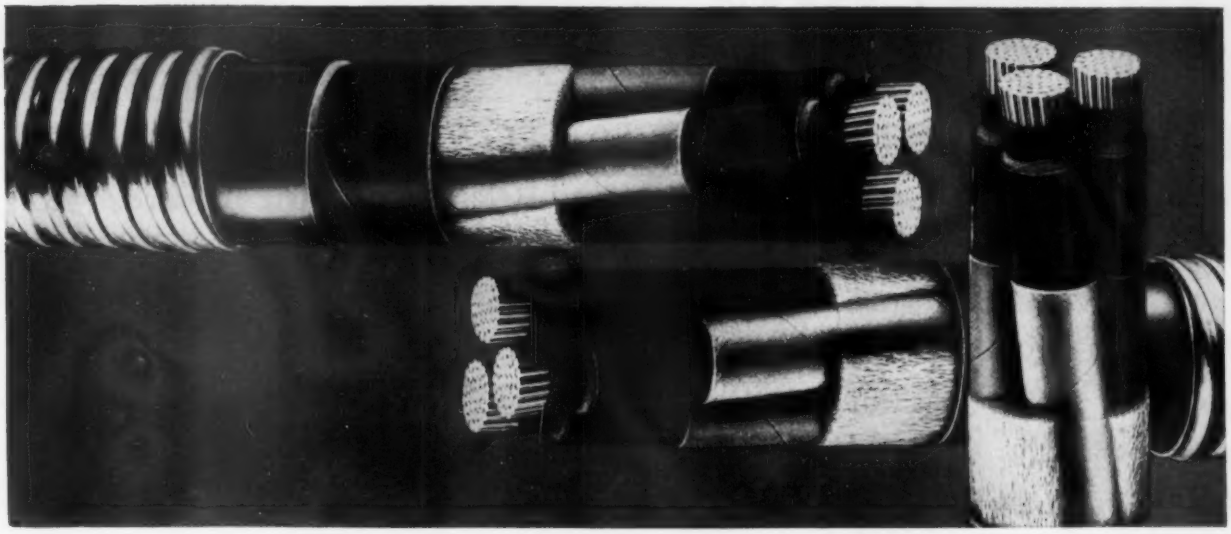
Ease of maintenance. Armorlokt Cable permits the greatest possible ease of maintenance. Cable faults are readily located and serviced. If Armorlokt should become damaged, you simply insert a splice box.

USS Tiger Brand Armorlokt Cable is available in voltage ratings from 110 to 15,000 . . . with galvanized, stainless steel, aluminum or bronze armor . . . with polyvinyl chloride jackets over the armor for especially corrosive applications. For complete facts, write American Steel & Wire, Dept. 983, 614 Superior Avenue, N.W., Cleveland 13, Ohio.

USS, Tiger Brand and Armorlokt are registered trademarks

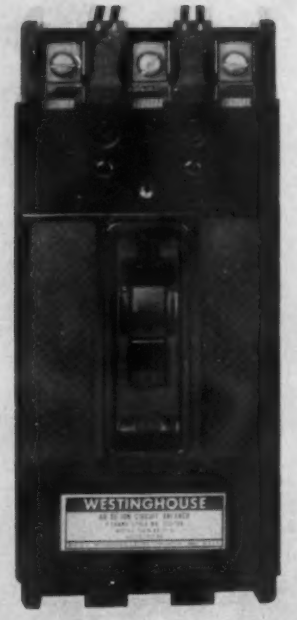
American Steel & Wire Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, Distributors Abroad



WHO ELSE MAKES THIS MANY TYPES OF CIRCUIT BREAKERS?

TRI-PAC†
current-limiting breaker for 100,000-amp faults



THERMAL-MAGNETIC
the industry standard

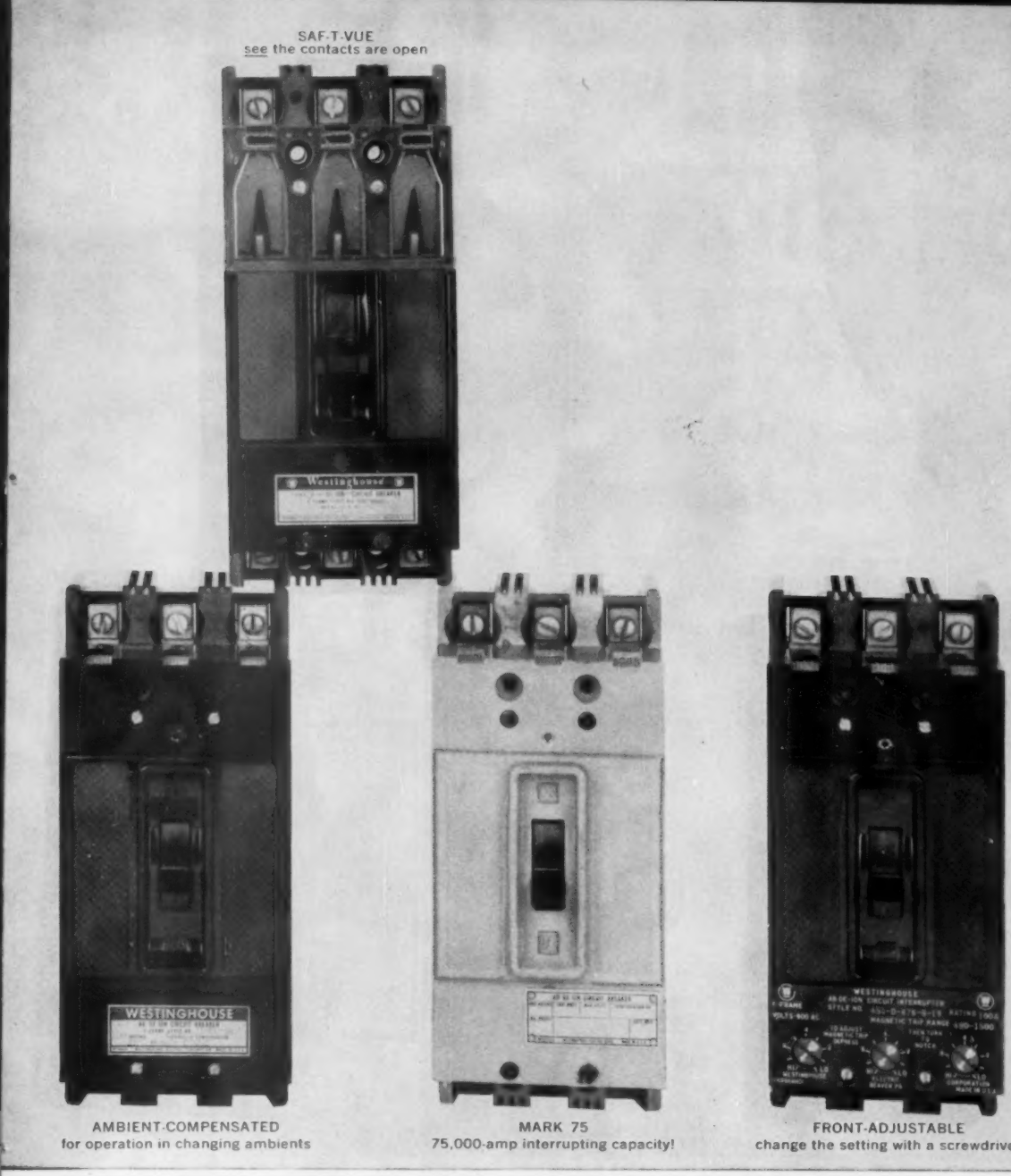
NOBODY BUT WESTINGHOUSE! It's true! Only Westinghouse offers you six complete lines* of circuit breakers–to solve six different kinds of circuit protection problems.

Here's what that means to you: You don't have to accept any "cure-all" type of breaker for your special applications. You can get the right breaker–designed by Westinghouse to do just that special job.

And these aren't high-priced "special" breakers. They're Westinghouse

*Three of these breaker lines are Westinghouse exclusives!—(Saf-T-Vue,† Ambient-Compensated, MARK 75†)

†Trade-Mark



AMBIENT-COMPENSATED
for operation in changing ambients

MARK 75
75,000-amp interrupting capacity!

FRONT-ADJUSTABLE
change the setting with a screwdriver

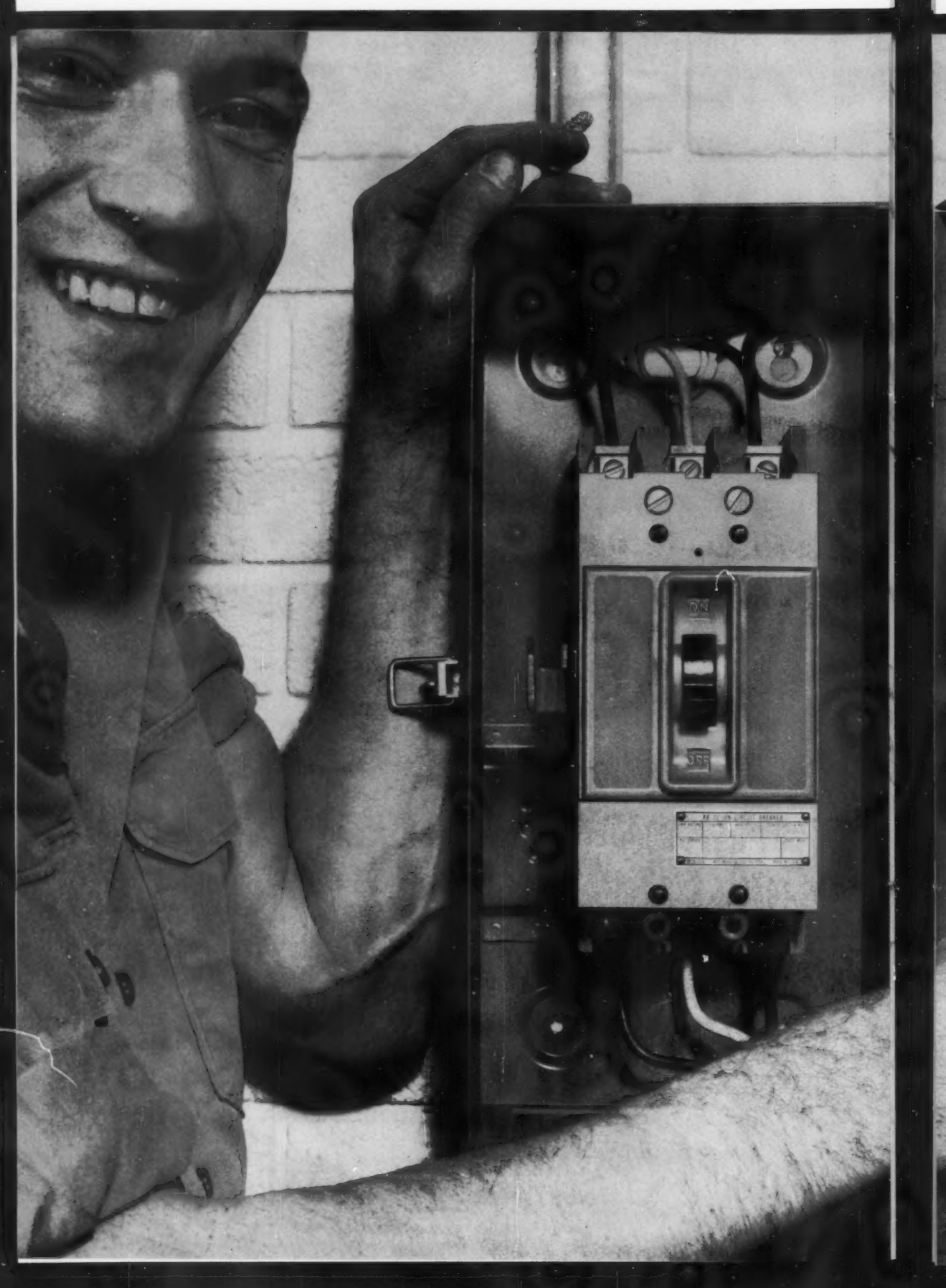
standards–available now in most any frame size, rating or interrupting capacity–in literally thousands of combinations.

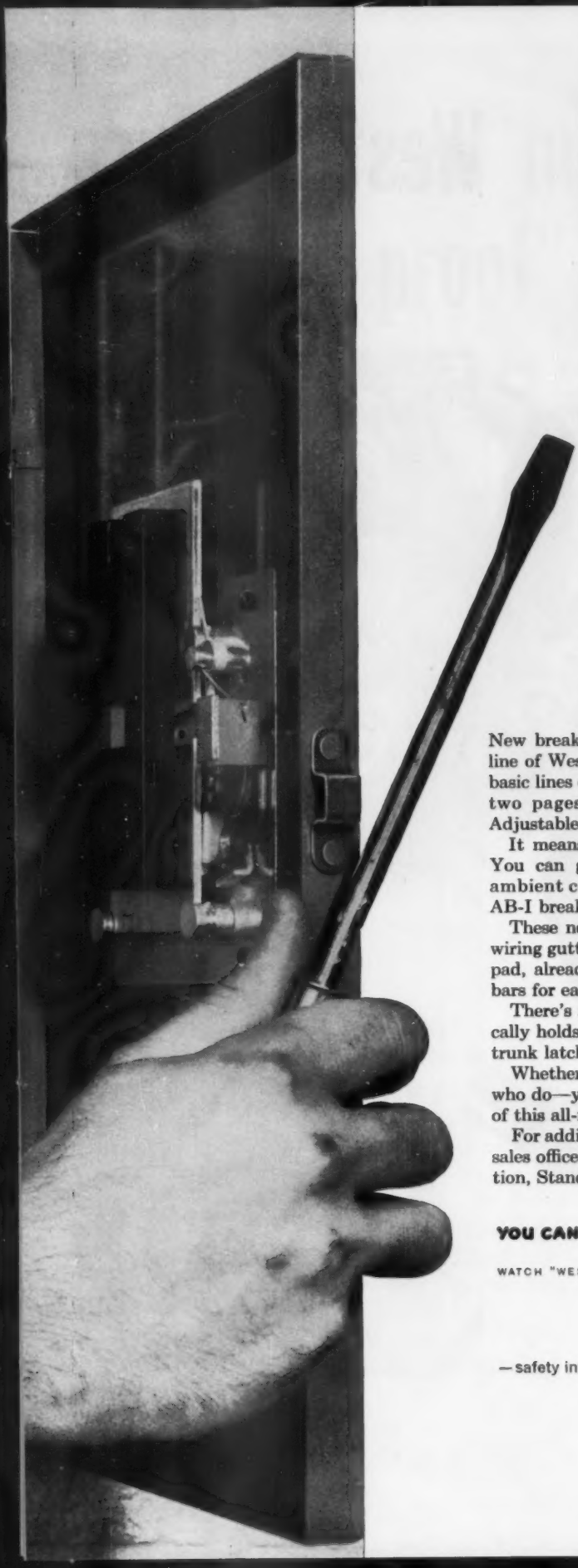
We suggest that next time you've got a problem involving circuit protection, call on Westinghouse. Chances are the answer is already in our warehouse. For further information on industry's only complete line of circuit breakers, please contact Standard Control Division, Westinghouse Electric Corporation, Beaver, Pa. Or call your nearby Westinghouse sales office.

J-30263

YOU CAN BE SURE...IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS


ON
OFF



AND NOW... WESTINGHOUSE GIVES YOU NEW ENCLOSURES

for industry's only complete line of circuit breakers

New breakers! New enclosures! Both from Westinghouse!! This new line of Westinghouse AB-I breakers is designed to hold *any* of the six basic lines of Westinghouse circuit breakers described on the preceding two pages. Mark 75—Ambient-Compensated—Tri-Pac—Front-Adjustable—Thermal-Magnetic—Saf-T-Vue—*any* of them!

It means almost unlimited versatility for your AB-I installations. You can get 100,000-amp interrupting capacities, visible contacts, ambient compensation... all with this new line of Westinghouse AB-I breakers.

These new enclosures are a cinch to install, too. They've got wide wiring gutters, well-placed knockouts and side-hinged covers. A neutral pad, already drilled and tapped, accepts a complete range of neutral bars for easy field installation.

There's also an optional safety interlock (see below) that automatically holds the breaker handle "off" when cover is opened. And a new trunk latch on the cover for an easy-to-close, dustproof seal.

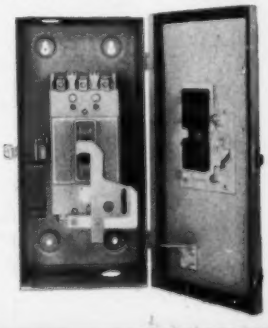
Whether you wire these new AB-I's yourself—or supervise the men who do—you're going to appreciate the time savings and adaptability of this all-new AB-I lineup.

For additional information, please contact your nearby Westinghouse sales office or distributor. Or write to: Westinghouse Electric Corporation, Standard Control Division, Beaver, Pa. J-30267-R

YOU CAN BE SURE...IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

Westinghouse EXCLUSIVE
—safety interlock available as low-cost optional!



Westinghouse with six

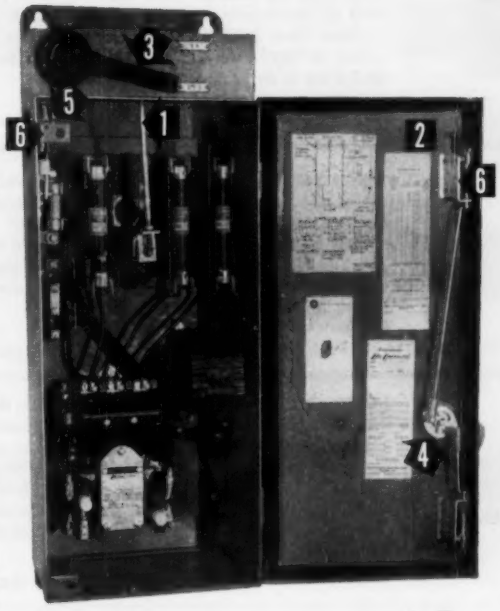
develops new motor starters "monkey proof" safety features

Westinghouse NEMA 12 Life-Line combination starters end unauthorized tampering, offer greater safety and convenience to service personnel

Check these six great new safety "firsts"...

1. The disconnect is permanently attached to handle. On-Off handle is not disengaged by opening the door.
2. Door must be fully closed and sealed before On-Off handle will operate disconnect. (See point 5, below.)
3. Operating mechanism can be padlocked to prevent operation.
4. Door opens simply, easily with tool (screwdriver). Cannot be opened with bare hands alone.
5. If desired, On-Off handle and disconnect can be operated with door opened. To operate, simply depress safety release.
6. Interlock assembly will not allow door to be opened while handle is in ON position. Removing spring from assembly will permit this if desired.

J-30273



. . . plus these extra important features, at no extra cost!

- NEMA 12 dustproof enclosure meets all JIC and other heavy industry specifications.
- Molded nylon handle for increased impact strength.
- Provision for padlocking door and handle.
- Tilted top to drain liquids away from door seal.
- Adjustable tie-rod between handle and disconnect to allow either switch or circuit breaker.
- Available in four standard sizes, from 1 through 4.
- Adequate internal wiring space.
- Extra space for third and fourth overload relays and excess capacity transformer.
- Auxiliary contacts can be field mounted in Visi-Flex* disconnect switch.
- All parts and complete panel removable from front.
- Components available for custom panel construction.

Call your local Westinghouse representative or distributor now, or write Westinghouse Electric Corporation, Standard Control Division, Beaver, Pa.

*Trade-Mark

YOU CAN BE SURE... IF IT'S Westinghouse

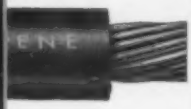
WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

Simplex PRODUCTS GUIDE

SIMPLEX WIRE & CABLE CO., CAMBRIDGE 39, MASSACHUSETTS, U.S.A.

ANHYDREX — Simplex ANHYDREX insulation, with over thirty years of success behind it, is universally accepted as a truly "all-purpose" insulation.

CATALOGUE #1028

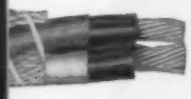


ANHYDROPRENE — Simplex ANHYDROPRENE Cables are designed for economical installation in ducts, conduits, racks, trays and raceways. Stock sizes AWG 14 to 1000 MCM are recommended for 75 C service in wet or dry locations. Other ANHYDREX compounds are available for service to 5000 volts with conductor temperatures of 90 C in wet or dry locations.
(U.L. labels available as appropriate)

CATALOGUE #1028

ANHYDREX-NEOPRENE — Simplex ANHYDREX-NEOPRENE Cables have the added mechanical protection necessary for aerial and direct burial service. Stock sizes AWG 14 to 1000 MCM are recommended for 75 C service in wet or dry locations. Other ANHYDREX compounds are available for service to 5000 volts with conductor temperatures of 90 C in wet or dry locations.
(U.L. labels available as appropriate)

CATALOGUE #1028



ANHYDREX-PLASTEX — Simplex ANHYDREX-PLASTEX (ANHYDREX-insulated, PLASTEX-jacketed) Cables are scientifically designed for compatibility between insulation and jacket, and for perfectly balanced performance in ducts, conduits, aerial and direct burial installations. ANHYDREX-PLASTEX Cables are recommended for service in a number of environments but especially where oils and chemicals are a problem.

CATALOGUE #1028

ANHYDREX Insulated Control Cables — Simplex ANHYDREX Control, Signal and Communication Cables have an additional thickness of appropriately coded neoprene over each individual conductor, plus heavy-duty neoprene jackets. ANHYDREX insulation provides excellent signal reproduction and is exceptionally stable, even when operating with high ambient temperatures.

CATALOGUE #1028

ANHYDREX XX — Simplex ANHYDREX XX is a butyl-based insulation of the highest possible quality. Because of its exceptional resistance to heat and ozone, it has general applications in circuits operating up to 35,000 volts, with permissible conductor temperatures of 90 C. to 5KV, and 85 C to 17KV — in wet or dry locations.

CATALOGUE #1023

CONDEX — Simplex CONDEX Cables are protected against mechanical damage by interlocked metallic armor. The armor is manufactured of galvanized steel, plain or baked enameled (colored) aluminum, bronze or other metals, and can be applied over any cable core within a very wide diameter range. CONDEX Cables may be further protected by a thermoplastic covering over or under the metallic armor.

CATALOGUE #1024

TIREX SO and SJO Cords — TIREX SO and SJO Cords are constructed to meet the most rigid specifications. All of their special features are carefully selected and processed to give maximum qualifications for portable service. They will twist without kinking, and bend without breaking. TIREX stranding affords maximum flexibility without sacrificing strength.

Conductor temperature rating 75c

CATALOGUE #992

TIREX Low Voltage Portable Cables — TIREX Low Voltage Cables are individually designed for specific applications. They are practically indestructible when used to do the work for which they are intended.

Conductor temperature rating 75c

CATALOGUES #992 & #1011

TIREX High Voltage Portable Cables — TIREX High Voltage Portable Cables have unequaled strength and versatility. Designed primarily to transmit energy to mobile electrical equipment, they are also used as temporary power lines during alterations or emergency repairs.

Conductor temperature rating 75c

CATALOGUE #1012

TIREX Mine Locomotive Cables — TIREX Mine Locomotive Cables — both single and two-conductor concentric — are approved by the Bureau of Mines and have the raised marking "P-101 BM" on their heavy-duty neoprene jackets. All TIREX Cables are cured and conditioned for service in lead.

Conductor temperature rating 75c

CATALOGUE #1012

TIREX Mining Machine and Shuttle Car Cables — TIREX Mining Machine and Shuttle Car Cables are designed for stability under today's rigorous mining conditions. The insulated conductors are "ribbed" or gear-shaped. This feature causes them to interlock with the heavy duty neoprene jacket and prevents them from slipping. Both Type W and Type G have "P-101 BM" molded onto the jacket.

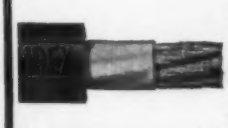
Conductor temperature rating 75c

CATALOGUE #1012

TIREX Dredge and Shovel Cables — TIREX Dredge and Shovel Cables are masterpieces of engineering achievement. Every consideration has been given to safety and durability. Simplex special cured-in-lead neoprene armor effectively resists all the elements normally encountered in this type of work.

Conductor temperature rating 75c

CATALOGUE #1012



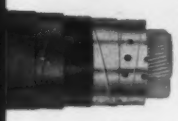
TIREX Welding Cables —TIREX Welding Cables are scientifically stranded for maximum flexibility without wrist drag. Cured-in-lead neoprene jackets provide utmost safety for both operator and bystanders.

Conductor temperature rating 75c

CATALOGUE #1011

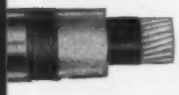
AND CATALOG REFERENCE

Please address requests to the Simplex home office in Cambridge or to your nearest Simplex district office.



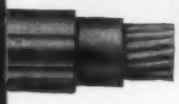
Simplex Paper Insulated Cables — Simplex Paper Insulated Cables are individually designed for specific jobs. They are available as either single or multiple conductor cables. The stranding may be round, segmental, sector or compact. Lead sheaths, reinforced neoprene jackets, or combinations of these are available for protection against moisture.

Simplex Polyethylene Insulated Cables — The versatility of Simplex Polyethylene has increased tremendously during the last ten years. Research has adapted it, not only to control and communication circuits, but also for power applications up to 35,000 volts. Our experience in this specialized field is unmatched by any other cable manufacturer.

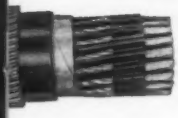


Simplex SIMCONEX Insulation — SIMCONEX (Simplex silicone) Insulated Cables are specially designed for service where unusually high operating temperatures prevail. SIMCONEX may be specified on all types of power, control, and communication cables. It is practically immune to ozone and corona and, with its minimum temperature rating of 125 C, it has the greatest resistance to heat of any known thermosetting insulation.

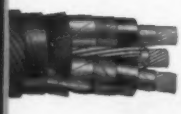
CATALOGUE #1032



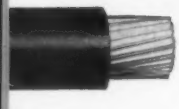
Diesel Locomotive Cables — Diesel Locomotive Cables are specially insulated and jacketed for 90 C service in the following applications: generator leads, motor leads, power jumpers, control jumpers, lighting systems, headlight wire, controller wiring, and cab signal wire. Highly flexible stranding promotes easy installation.



Antimicrophonic Cables — Simplex Antimicrophonic Cables are adaptable wherever extremely fine measurements are to be made. They will not produce spurious voltages when compressed, deformed or subjected to violent shock. Can be manufactured with a varying number of conductors and conductor sizes.



Bore Hole and Shaft Cables — Bore Hole and Shaft Cables are generally insulated with Simplex ANHYDREX moisture-resistant insulation. Mechanical protection is provided by galvanized or stainless steel, copper, copperweld or other appropriate round wire armor. PLASTEX jackets may be specified over or under the wire armor.



PLASTEX Apparatus Wire — Simplex PLASTEX Apparatus Wire — for machine tool, switchboard wiring and other similar applications. Simplex PLASTEX is available to meet a wide range of operating temperatures.

C-L-X Sheaths — Simplex C-L-X is a continuously corrugated, pliable, lightweight, exterior metallic cable sheath which is impervious to gases, chemicals, and water. Its unique construction makes it adaptable to nearly all environments or services and gives it a combination of properties unmatched by any cable system now manufactured. C-L-X is appropriately called "the metallic duct with built-in cable."

CATALOGUE #1031

ANHYDREX Submarine Cables — Simplex ANHYDREX Submarine Cables for power, control and communication circuits are designed from experience dating back to 1920. (The moisture resistance of ANHYDREX made possible the first nonleaded submarine cables.) High tensile strength armor wires of steel or other appropriate metals provide the best possible mechanical protection.

Self-Supporting Aerial Cables — Simplex Self-Supporting Aerial Cables for power, control and communication circuits practically eliminate the necessity of tree trimming. They are completely assembled at the factory and ready for installation. Because of this, they are extremely easy to handle and cut installation cost to a fraction of what it would normally be.

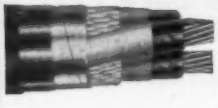
CATALOGUE #1006

Lead Covered Cables — When a customer's specifications demand a lead sheath, Simplex has full facilities for its manufacture. A number of high-grade lead alloys are available including tellurium, copper bearing and arsenical. Recent studies enable Simplex engineers to recommend the most appropriate lead sheath alloy for your particular application.

Railroad Signal and Communication Cables — Railroad Signal and Communication Cables may be insulated with either ANHYDREX or Polyethylene, with mechanical protection, according to individual needs. Bronze tapes are usually provided in direct burial constructions.

Cathodic Protection Cables — Cathodic Protection Cables are used to equalize voltage potential between metallic structures and the earth. Simplex ANHYDREX or Polyethylene insulations may be specified with complete confidence.

CATALOGUE #1033

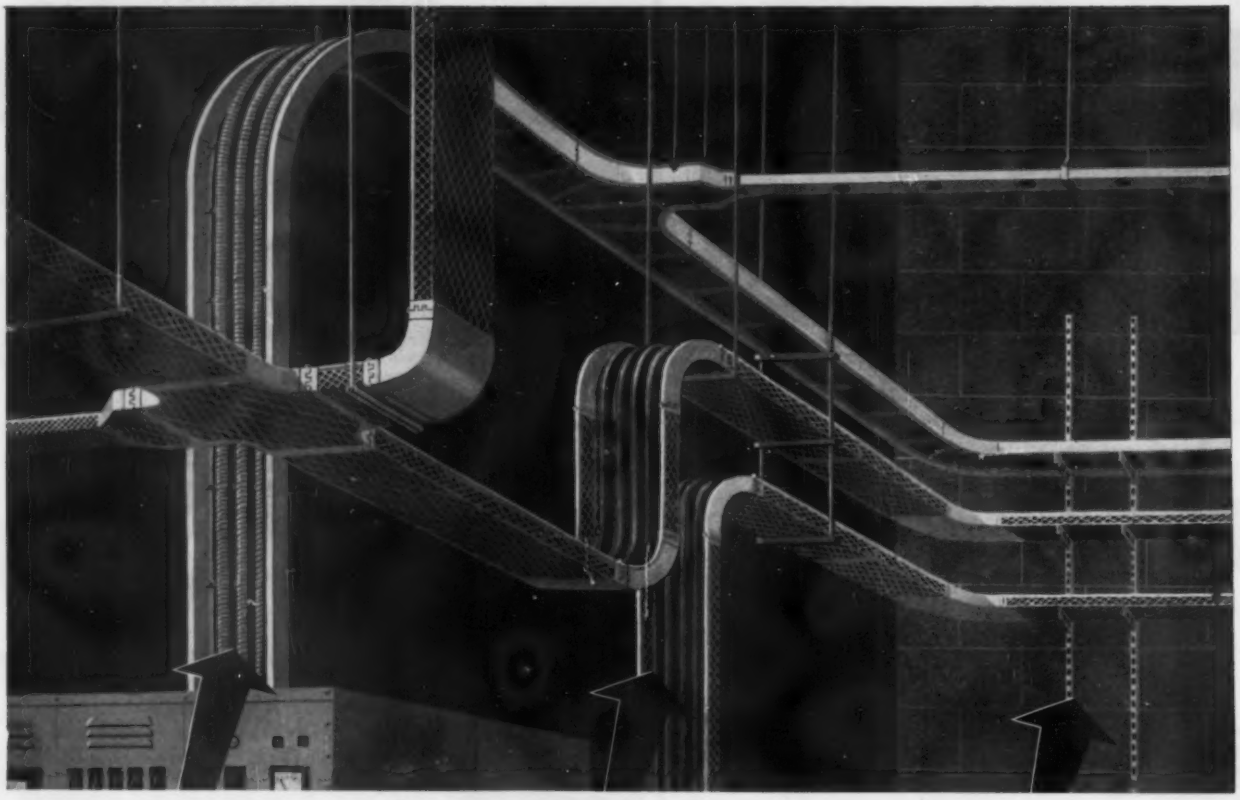


Simplex Varnished Cambric Cables — Simplex Varnished Cambric Cables are particularly suited for station or power house wiring, or for any service where the operating temperature is high. Between each layer of varnished cambric is a plastic filler compound which is nonhardening, and nonmigrating. It allows the tapes to slip one upon the other without danger of wrinkling.

BULLETIN #108

COPE SYSTEMS

MEET EVERY CABLE DISTRIBUTION REQUIREMENT



LADDER and CHANNEL for Support of Interlocked Armored Cable and Individual Branch Runs

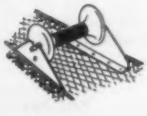
- All Cope Systems Feature Exclusive Cope Pin-Type Coupler for Faster Assembly Without Special Tools
- Lightweight, Easy to Handle—Choice of Hot Dip Galvanized or Aluminum
- Fittings Supplied Complete Ready to Go—No Extras to Bother With on the Job
- Provides Maximum Installation Flexibility—For Changes in Width, Direction, Elevation and Cable Dropouts
- Provides for Easy System Expansion in Future

WIREWAY for Primary Power and Secondary Distribution Circuits

- Simplifies Installation on Any Job—Large or Small
- Supports More Cable in Less Space than Conduit—Over 1,000 Interchangeable System Components—Straight Sections and Fittings—to Fit Any Type Layout
- Available in Durable Expanded Metal—Lightweight Aluminum or Hot Dip Galvanized Steel Construction
- Prompt Delivery Through Nearby Wholesalers

SYSTEM SUPPORTS and ACCESSORIES

- Interlocking Steel Supports for Easy, Low Cost Installation of Wireway, Ladder and Channel Systems
- Complete Line of Sheaves and Cable Rollers Speeds Installation of Cable

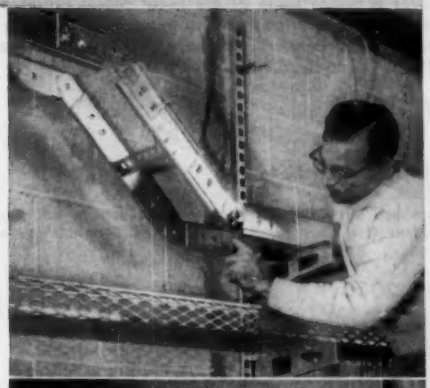


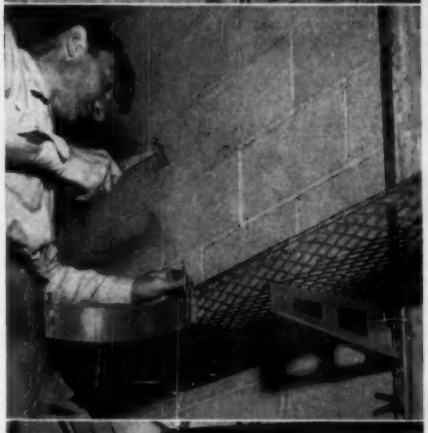
PLUS NEW CONTROLWAY—LOWEST COST SUPPORT FOR LOW VOLTAGE CONTROL AND SIGNAL CIRCUITS

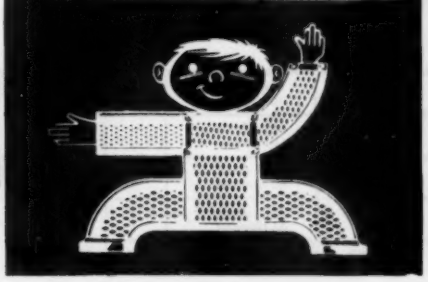
COPE SUPPORTING SYSTEMS AND EQUIPMENT ARE SOLD ONLY THROUGH AUTHORIZED COPE ELECTRICAL WHOLESALERS

A COMPLETE INTEGRATED LINE OF SUPPORTING SYSTEMS FOR ELECTRICAL POWER AND CONTROL CABLES

COPE SYSTEMS... SAVE 3 WAYS







1 LOWER FIRST COST

A single run of Cope Wireway or Ladder supports as many cables as several runs of conduit. From the start, customer material costs are lower . . . space requirements kept to a minimum.

2 LOWER INSTALLATION COST

Strong, yet lightweight, Cope system components are easy to handle, quick to install—even in the most cramped quarters. Fast, easy connections are made with Cope's exclusive pin-type coupler, while interchangeable Wireway, Ladder and Channel components speed system installation.

3 LOWER MAINTENANCE COST

Easy-to-get-at Cope systems cut maintenance costs, too . . . permit ready re-routing of existing cables or addition of new cables for future expansion needs. Cope supporting systems are available in a variety of widths and straight section lengths to fit specific layout requirements.

Originators of First Integrated Line of Cable Supporting Systems:
WIREWAY • LADDER • CHANNEL • CONTROLWAY

COPE

Division of ROME CABLE CORPORATION
COLLEGEVILLE, PENNSYLVANIA

WIREMOLD® SURFACE METAL RACEWAYS

THE WIREMOLD COMPANY • DEPT. E5, HARTFORD 10, CONNECTICUT

PLUGMOLD® Multi-Outlet Systems

Cover a wide range of electrical outlet requirements — for new construction or rewiring jobs. Mount on any surface . . . walls, work benches, counters, displays, etc. A minimum of fittings is required.

NO.1900

Furnished three ways: unwired (space outlets as desired); factory-wired sections (for short runs); and prewired Snapicoil (outlets on various centers).

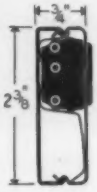
NO.2000

One size raceway accepts three types of outlets—2-wire NEMA grounded and 2- and 3-wire duplex. Furnished either as pre-wired Snapicoil (outlets 30" or 60" on centers), or factory-wired sections with closer spaced outlets (for short runs).

NO.2100

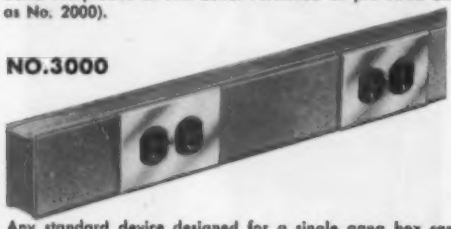
Furnished unwired (space outlets as desired). Receptacles available include 2-wire, 2- and 3-wire grounded, lumiline single, midget twistlock, 3-wire polarized, 3-wire polarized grounded, and T-slot.

NO.2200



A combination multi-outlet system, wiring raceway and steel baseboard. Same receptacles as No. 2000. Furnished as pre-wired Snapicoil (same as No. 2000).

NO.3000



Any standard device designed for a single gang box can be installed wherever needed within the raceway. Standard flush plates are used.

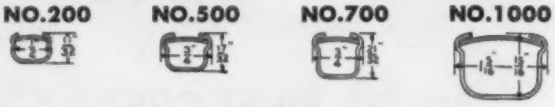
CAPACITY (for wire types T, TW, RU)

PLUGMOLD		CONDUCTOR SIZE NO. 6	NO. 8	NO. 10	NO. 12	NO. 14
NO. 1900	with devices	—	—	—	3	3
	no devices	—	—	—	3	3
NO. 2000	with devices	—	—	—	3	3
	no devices	—	—	—	3	3
NO. 2100	with devices: consult Wiremold Catalog No. 21					
	no devices	5	8	10	10	10
NO. 2200	with devices	3	7	10	10	10
	no devices	5	8	10	10	10
NO. 3000	with devices	8	10	10	10	10
	no devices	10	10	10	10	10

WIREMOLD® Surface Wiring Raceways

Used along ceilings and walls — to modernize existing wiring, or complete new wiring from panel box to outlets. A minimum of fittings is needed. Four sizes; furnished as one-piece raceways.

NO.200 **NO.500** **NO.700** **NO.1000**



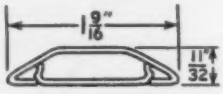
CAPACITY (for wire types T, TW, RU)

WIREMOLD	CONDUCTOR SIZE NO. 6	NO. 8	NO. 10	NO. 12	NO. 14
NO. 200	—	—	—	3	3
NO. 500	—	2	3	4	5
NO. 700	—	3	5	6	8
NO. 1000	5	8	8	10	10

PANCAKE® Overfloor Duct Systems

Strong, flat overfloor raceways to carry power and light and communications wiring to locations away from walls. Quickly installed without channeling into floors. A minimum of fittings is needed.

NO.1500



CAPACITY

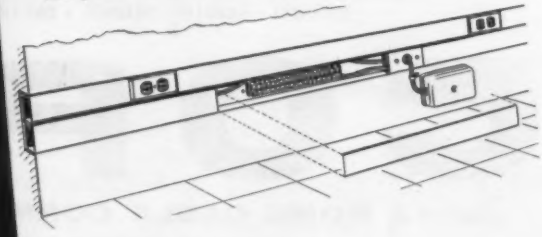
CONDUCTOR SIZE:	NO. 8	NO. 10	NO. 12	NO. 14
wire types T, TW, RU	4	4	6	8

NO.2600 (not shown)

CAPACITY: two 26-pair telephone cables.

TELE-POWER Duct Systems

Consist of a pair of parallel Plugmold Raceways — one for telephone, signal and inter-office communications wiring; the other a multi-outlet system for power and light wiring. Because each raceway has a separate cover, the electrical contractor or telephone installer needs only install or remove the cover for the wiring that concerns him. The high and low potential wiring are not exposed to each other.



your control cable problems end here

PLASTICOTE® INSULATED AND JACKETED CONTROL CABLE

Of all cable products, Control Cable has the greatest responsibility in safeguarding life and property . . . for on its unfailing function rests the immediate response to fire alarms, the constant operation of power station control circuits, the quick action of police and day-after-day traffic control. Chester's light weight, unusually pliable and highly resistant Plasticote insulated and jacketed Control Cable meets the strict Industry Standard specifications for all of these vital services. At the same time, Chester solves cost problems, too, with long life, trouble-free cable for direct earth burial, overhead and flexible lines in building installations. In many cases, physical and electrical properties exceed those of other types of insulation. Careful attention to all these needs, vital to service and installation, makes Chester Plasticote Control Cable a preferred brand for municipal services . . . for power station and supervisory circuits . . . for flexible or extension connections. Electrical men know that Chester cable is *custom engineered for the END result!*

CHESTER CABLE CORP., CHESTER, NEW YORK
A SUBSIDIARY OF MIAMI COPPER COMPANY

Complete data on Chester Control Cable is available on request. Ask for Bulletin No. ECC-1

Specify Chester Wire and Cable For All Your Electrical Equipment Needs

Control Cable • Bus Drop Cable • Service Cord • Safety Control Wire • Thermostat Cable • Underground Feeder Cable • Bell Wire • Machine Tool Wire • Armored Bushed Cable • Building Wire • TV Lead-in • Train Wire • Ignition Cable Flexible Conduit • Bare Copper Wire • Service Entrance Cable • Mine Service Wire & Cable • Hook-up Wire • Telephone Wire

New ORANGEBURG® CA* CONDUIT *with Flush Coupling Attached!*

With no separate couplings to handle or attach on the job, Orangeburg CA lays faster, costs less to install. Each long, light length has a *flush* coupling attached at one end and a standard 2° male taper at the other end, making installation a simple, one-step operation. And, since the coupling *is* attached, there are no coupling cartons to warehouse or carry to the job.

What's more, with the coupling *flush* to the conduit's outside wall, new CA is easy to stack, store and handle. The flush coupling also eliminates "staggered" joints in the trench. And that means real savings in cutting and tooling time.

Like the hundreds of millions of feet of Orangeburg fibre conduit in use since 1893, new CA has self-sealing joints and impermeable walls. Its smooth, 100% fibre raceway adds years to cable life.

New Orangeburg CA is available in 2", 3", 4", 4½" and 5" sizes. Orangeburg Standard and Nocrete Conduit, with separate sleeve couplings, are available as always. Write Dept. **EC-59** for Catalog 52.

ORANGEBURG MANUFACTURING CO.
Orangeburg, New York • Newark, California
A Division of The Flintkote Company, Manufacturers of America's Broadest Line of Building Products

Orangeburg Fibre Conduit is distributed by Graybar Electric Co. and General Electric Supply Co. with branches and stocks in principal cities.

GEDNEY

TOPS THEM ALL!

...in malleable iron quality
...in accurate machining
...in smooth-fitting threading

ROCK-BOTTOM INSTALLATION COSTS... specify Gedney. Machined and threaded with utmost accuracy...smooth-finished, with no metal particles or burrs ... made of the best malleable iron to eliminate breakage...individually inspected to insure absolute top quality. For today's lowest installation cost.... specify Gedney!

LIQUID-TITE CONNECTORS

The most dependable liquid-tight connectors available today. For use with "SEALTITE" and equivalent Liquid-Tite Flexible Conduit. Designed to give wiring absolutely dependable protection against water and oil. Built for lifetime service. Available in sizes ½" to 2"... straight... 45° and 90°.

90° CORNER ELLS

Top-quality Malleable Iron, cadmium plated. Fitted with gasketed cover. Both ends female. Available in a full range of sizes from ½" to 2".

90° CORNER ADAPTERS

Top-quality Malleable Iron, cadmium plated. Fitted with gasketed cover. One end male, one end female. In sizes from ½" to 2".

GEDNEY FITTINGS FIT

GEDNEY
ELECTRIC COMPANY

GEDNEY

RKO BLDG., RADIO CITY, NEW YORK 20
Foundry, Factory and Shipping Point: Terryville, Conn.

Along today's modern highways easy-to-handle J-M Transite Ducts provide installation economies and years of service life, protecting traffic-signal, lighting, and other power-service circuits.

J-M Transite® Ducts install fast to last... give complete cable protection.

Because speed and economy set the pace in today's highway programs, more and more highway cables are going into Johns-Manville Transite Ducts.

For speed, Johns-Manville Transite Ducts are strong, light and long—easy to handle and install. Workmen set 10-foot lengths in place easily, join them up tight in seconds with snug-fitting J-M Plastic Couplings, and Transite's smooth bore is free of burrs and other obstructions that may interfere or cause damage during pulling of cables.

For economy, J-M asbestos-cement Transite Ducts go in to stay. Non-conductive Transite is not affected by electrolysis—resists the corrosive action of fills or high-salt soils in permanently damp locations. Millions of feet of installed Transite Ducts have proved that Transite withstands earth loads and soil stress... resists vibration and shock from highway traffic.

Let us send you free Transite Duct brochure EL-29A. Write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville Asbestos Transite Ducts can be laid directly in trench without concrete envelope or other mechanical protection.

JOHNS-MANVILLE Transite Ducts

Made of Asbestos-Cement

J-M Conduit for direct buried banks and exposed runs
J-M Korduct® for concrete banks

New GE5451-2 20-amp a-c switch, only 1¾" at deepest point, relieves crowding of wires.

Shallow 20-ampere, 277-volt G-E switch leaves more room for wiring

Call your General Electric distributor today!

You'll like the extra room this new General Electric a-c switch gives you in the box. It's Specification Grade, and listed by Underwriters' Laboratories, Inc. for 20A—277V, yet is considerably shallower than other heavy duty types. Provides easier installation . . . insulated terminals prevent grounds or shorts.

You get other G-E features too: silver contacts — screwless Pressure-Lock* terminals — ⅞" plaster-cleaning mounting screws held captive in the gold color strap that identifies a 20A switch. Takes #14, 12 or 10 Awg wire.

Your General Electric distributor can give you expert advice about the complete line of General Electric Wiring Devices for residential, commercial and industrial applications. G-E devices provide the improved features you need. General Electric Company, Wiring Device Department, Providence 7, R. I.

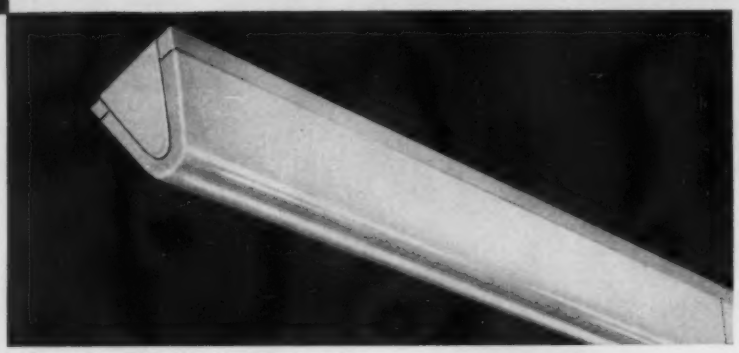
*Trade-mark of General Electric Company

Progress Is Our Most Important Product

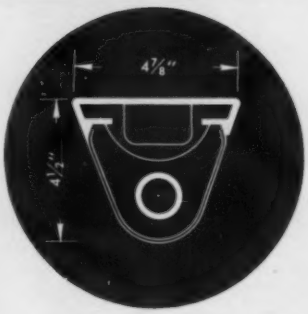
GENERAL ELECTRIC

THIS WAY PLEASE

details make the difference



There are good reasons why so many lighting specs hold firm for this newly-redesigned Lightolier corridor unit: ARCHITECTS like the smooth line of light from the 4-foot molded styrene diffuser...the neat, clean end detail with no exposed screws. OWNERS like the finished appearance of Modular Sightron...its easy maintenance...its efficient, dependable performance. CONTRACTORS like the new hidden hinges that keep plastics securely in place, eliminate return trips ...the installation time saved because one diffuser now takes the place of two...the maximum profits. Doesn't it make good sense to recommend and install commercial lighting by Lightolier? For a 120-PAGE CATALOG-BINDER detailing the complete collection, write Dept. EC-59



LIGHTOLIER

ARCHITECTURAL LIGHTING • RESIDENTIAL FIXTURES • PORTABLE LAMPS

MAIN OFFICE AND FACTORY: JERSEY CITY 5, NEW JERSEY

These authorized Lightolier distributors can help you get more profitable orders:

ALABAMA
Birmingham: Mayer Elec. Sup. Co.

ARIZONA
Phoenix: Brown Wholesale Elec.

CALIFORNIA
San Francisco: California Elec. Sup. Co.

COLORADO
Denver: Central Elec. Sup.

CONNECTICUT
Bridgeport: B. M. Tower
Hartford: Beacon Light & Sup. Co.
New Haven: Grand Light & Sup. Co.
New London: United Elec. Sup. Co.
Stamford: Marie Co.

DISTRICT OF COLUMBIA
Maurice Elec. Sup. Co.
National Elec. Wholesalers
O. R. Evans & Bros.

FLORIDA
Miami: Farrey's Whsle. Hdwe. Co.

GEORGIA
Atlanta: Atlanta Ltg. Fix.
Noland Co.

ILLINOIS
Chicago: Efengee Elec. Sup. Co.
Englewood Elec. Sup. Co.
Hawkins Electric
Hyland Elec. Sup. Co.
Wholesale Elec. Sup.
Elgin: Fox Elec. Sup.
Rockford: Englewood Elec. Sup. Co.
Springfield: Springfield Elec. Sup.

INDIANA
Ft. Wayne: Mossman-Yarnelle Co.
Gary: Englewood Elec. Sup. Co.
So. Bend: Englewood Elec. Sup. Co.

IOWA
Des Moines: Weston Lighting Co.

KANSAS
Kansas City: W. T. Foley Elec. Co.

KENTUCKY
Paducah: Ohio Valley Sup.

LOUISIANA
Baton Rouge: Electrical Wholesalers
New Orleans: Interstate Elec. Co.

MAINE
Bangor: Standard Elec. Co.
Portland: Holmes Elec. Supply Co.

MARYLAND
Baltimore: Excello Public Serv. Corp.

MASSACHUSETTS
Boston: Mass. Gas & Elec. Light Co.
Henry L. Wolfers Inc.
Fitchburg: Service Elec. Sup. Co.
Pittsfield: Carr Supply
Springfield: Eastern Elec. Sup.
Worcester: Atlantic Elec. Sup.
Benjamin Elec. Sup.

MICHIGAN
Detroit: Madison Elec. Co.
Michigan Chandelier Co.
Flint: Royalite Co.
Grand Rapids: Purchase Elec. Sup. Co.
Pontiac: Standard Elec. Co.
Saginaw: Standard Elec.

MINNESOTA
Duluth: Northern Elec. Sup. Co.
Minneapolis: Charles A. Anderson & Co.
Northland Elec. Sup. Co.
St. Paul: Lax Elec. Co.

MISSOURI
St. Louis: M. K. Clark

NEBRASKA
Omaha: Electric Fix. & Sup. Co.

NEVADA
Reno: Western Elec. Dists. Co.

NEW HAMPSHIRE
Portsmouth: Mass. Gas & Elec. Light Co.

NEW JERSEY
Atlantic City: Franklin Elec. Sup. Co.
Camden: Camden Elec. Fix. Co.

NEW MEXICO
Albuquerque: Albuquerque Dist. Co.

NEW YORK
Albany: Havens Elec. Co. Inc
Binghamton: Freije Elec. Sup. Co.
Buffalo: Buffalo Incan. Light Co. Inc.
Niagara Falls: Hysen Sup. Co.
Poughkeepsie: Electra Sup. Co.
Rochester: Rowe Electric Sup. Co.
Syracuse: Superior Elec.

NORTH CAROLINA
Charlotte: Independent Elec. Sup.
Durham: Noland Co.
Greensboro: Elec. Sup. & Equip. Co.
Kinston: Kinston Elec.
Winston-Salem: Noland Co.

OHIO
Akron: The Sacks Elec. Sup. Co.
Canton: The Electric Sales
Cincinnati: B. & B. Elec.
F. D. Lawrence Electric Co.
Cleveland: H. Leff Electric
Columbus: Elgee Elec. Co.
The Loeb Elec. Co.
Dayton: Duellman Elec. Co.
Toledo: Gross Elec.
Youngstown: Mart Industries

OKLAHOMA
Tulsa: Lawson Elec. Co.

PENNSYLVANIA
Allentown: Coleman Elec. Co.
Erie: Kraus Elec. Co.
Harrisburg: Fluorescent Sup. Co.
Hazleton: Power Elec. Co. Inc.
New Castle: Midwestern Elec. Co.
Philadelphia: Ace Lighting Fix. Co.
Gold Seal Elec. Sup. Co.
Sylvan Elec. Fix. Co.
Pittsburgh: Allied Elec. Sup. Co.
Argo-Lite Studios
Doubleday-Hill Elec. Co.
Wally Elec. Sup. Co.
Reading: Coleman Elec. Co.
Scranton: Lewis & Reif
Wilkes-Barre: Anthracite Elec. Sup. Co.

RHODE ISLAND
Pawtuchet: Major Elec. Sup. Co.
Providence: Leavitt Colson Co.

SOUTH CAROLINA
Anderson: Sullivan Hdwe. Co.
Columbia: Capitol Elec. Sup. Co.
Noland Co.
Greenville: Sullivan Hdwe. Co.

SOUTH DAKOTA
Watertown: J. H. Larson Elec. Co.

TENNESSEE
Johnson City: Noland Co
Nashville: Nashville Elec. Sup. Co.

TEXAS
Dallas: Rogers Elec. Sup.
Ft. Worth: Anderson Fixture Co.
Houston: Martin Associates
San Antonio: Southern Equip. Co.

VIRGINIA
Arlington: Dominion Elec. Sup. Co. Inc.
Noland Co.
Lynchburg: Mid State Elec. Sup. Inc.
Norfolk: Noland Co.
Rosslyn: Noland Co.

WEST VIRGINIA
Charleston: Goldfarb Elec. Sup. Co.
Virginian Electric Inc.
Huntington: West Virginia Elec. Co.
Wheeling: The Front Co.

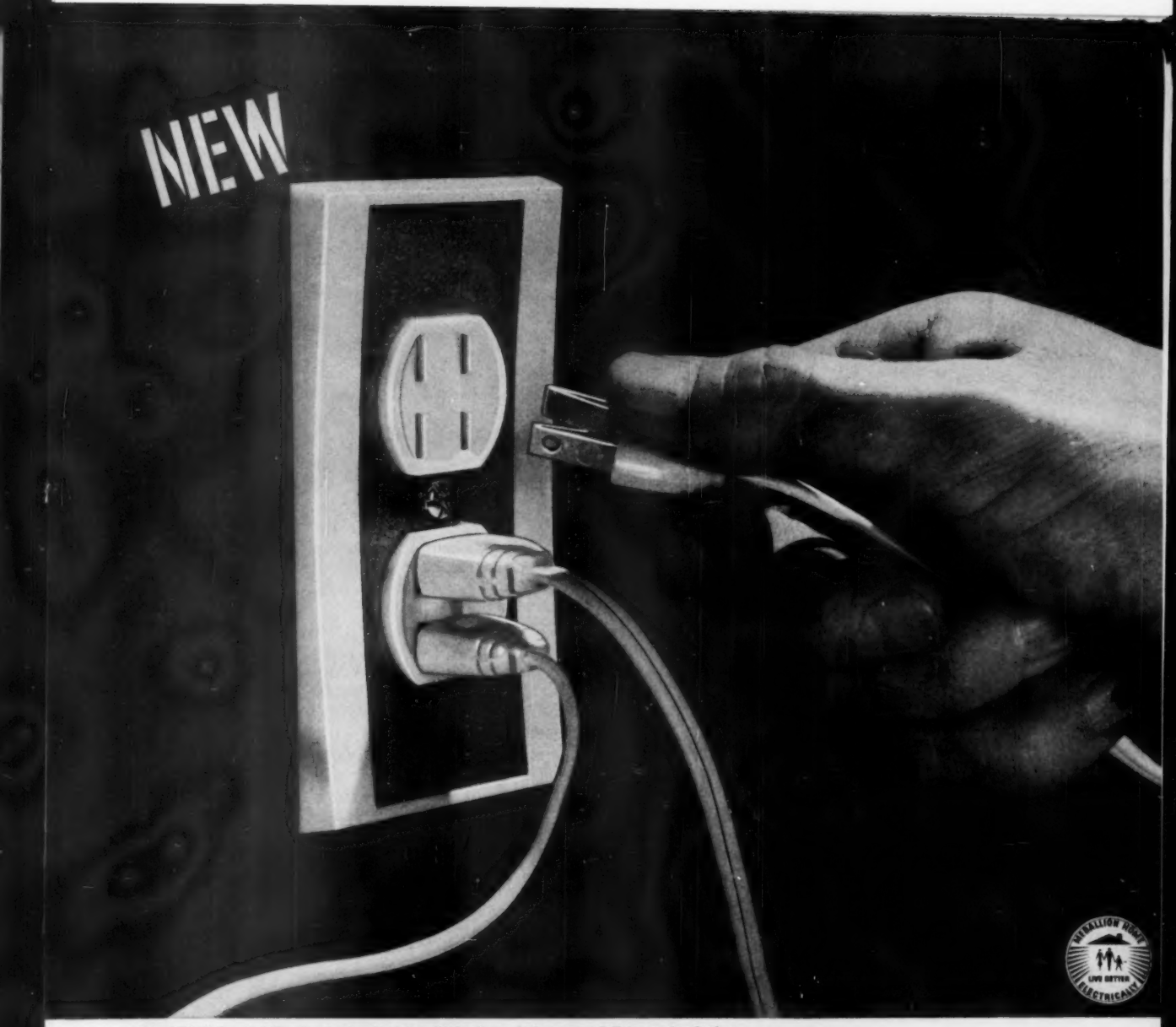
WISCONSIN
Appleton: Moe Northern Co.
Eau Claire: W. H. Hobbs Sup. Co.
La Crosse: W. A. Roosevelt Co.
Milwaukee: Lappin Elec. Co.
Standard Elec. Sup.

WASHINGTON
Seattle: Seattle Lighting Fix. Co.

ALASKA—*Anchorage:* Northern Supply Co.

CANADA
Montreal: The Gray Elec. Co.
Toronto: Revere Elec. Dist.
Toronto Elec. Sup. Co.

HAWAII
Honolulu: Hawaiian Light. & Sup. Co.



New GE4034-2 outlet fits standard wall plates. Plate shown is from new G-E Decorator Series.

4-plug outlet provides twice the outlets in same space

Call your General Electric distributor today!

Look close, and you'll see *two* pairs of contact slots in each face of this new G-E outlet. It accommodates up to *four* flat attachment caps — yet fits in the same space and uses the same wall plate as a conventional double outlet.

The G-E 4-Plug Outlet is valuable wherever lamps radios, electric blankets, etc., are likely to be concentrated, because it assures plenty of neat connections — prevents the build-up of "octopus" appearance. Screwless Pressure-Lock* terminals and 7/8" captive mounting screws save installation time. Has double-wipe contacts. Listed by U. L., meets Federal and R.E.A. specifications.

Ask your General Electric distributor for devices that provide the new features you've been looking for. General Electric Company, Wiring Device Department, Providence 7, Rhode Island.

*Trade-mark of General Electric Company

Progress Is Our Most Important Product

GENERAL ELECTRIC

Porter® VINYL TAPE

Unqualified approval by Westinghouse Refrigeration Division!

Porter Vinyl Tape has been tested to meet the tough Westinghouse specification for use in new refrigerator-freezer combinations, and has received unqualified approval on every point.

Westinghouse rated tapes on the following points: Breaking strength • Adhesion • Low- and high-temperature properties • Staining • Moisture-resistance • Elongation • Odor • Dielectric strength • Effect on polystyrene—and Porter met the spec's on every count!

Special new winding and slitting techniques keep Porter Vinyl Tape from telescoping on the roll, and help save space in tight spots where compact winding is essential. Another feature is its self-extinguishing property—it will not support combustion.

Get complete information by writing *Thermoid Division, H. K. Porter Company, Inc., Tacony & Comly Sts., Philadelphia 24, Pa.*

THERMOID DIVISION **PORTER** **H.K. PORTER COMPANY, INC.**

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION; Copper and Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

GE7604-2 switch and grounding outlet combination installs as single unit, fits double outlet plate.

Combination line devices with Pressure-Lock* terminals save time, cost less

Call your General Electric distributor today!

Install two devices as quickly as one! Each G-E Combination Line device contains two devices, pre-assembled in one housing, to fit standard double outlet plates. Two-switch, switch-outlet, switch-grounding outlet and switch-pilot light combinations come ready to install. Listed by Underwriters' Laboratories, Inc., meet Federal and REA specifications.

You save time with the General Electric Combination Line because internal jumper connections have been factory-made — and because screwless Pressure-Lock terminals and other features cut down the work that's necessary on the job . . . making time for more jobs.

Courteous General Electric distributor personnel will gladly show you how new ideas in dependable wiring devices will save you time and trouble . . . bring extra profit to you. General Electric Company, Wiring Device Department, Providence 7, R. I.

*Trade-mark of General Electric Company

Progress Is Our Most Important Product

GENERAL ELECTRIC

THIS WAY PLEASE

It's the revolutionary new

PTC "HUSH-FLUSH" DRY-TYPE TRANSFORMER

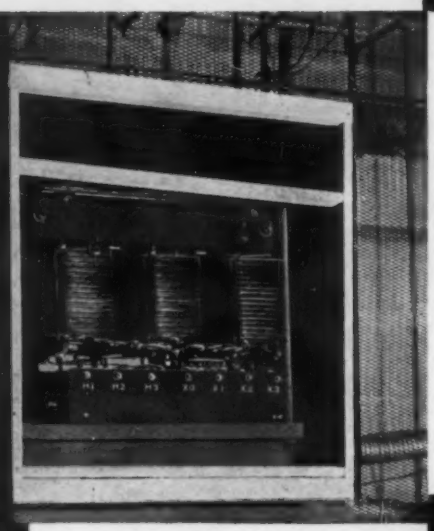
Amazingly quiet, efficient transformers for power, distribution and specialty use — perfect installation for: HOSPITALS, SCHOOLS, LIBRARIES, CHURCHES, OFFICE AND PUBLIC BUILDINGS, THEATERS, etc. where noise must be eliminated!

NOW...

reduce the size, cost and labor for feeders from remote power sources. Have economical electric energy at your most convenient locations, without noise or visible installations, in formerly unusable space.

New SPACE-SAVING DESIGN

- ★ Frees valuable space for profitable, productive use
- ★ Eliminates costly voltage drops and power losses
- ★ Improves interior appearance
- ★ Decentralizes power source
- ★ Reduces size of required feeders
- ★ Cuts cost of material and labor
- ★ Provides greater amount of electrical energy per unit cost



COMPACT, FULL ACCESSIBLE installation, needs only finish plastering before panel is secured on face.

EXPANDED METAL GRILLS ON FRONT PANEL attractive yet functionally designed for ventilation and cooling.

WHAT MAKES "HUSH-FLUSH" so whisper - QUIET?

Unusual design and rigid construction provide noiseless, vibration-free operation. The complete lining of sound-proofing material within the cabinet assures new quiet, never before possible.

WHY IT PAYS TO SPECIFY PRECISION

Check these quality details!

Type	Size	Dimensions in inches		
		Cabinet		
Phase	KVA	Hgh.	Wth.	Dph.
Single	50 37½	39⅛	20½	18½
	25	34⅝	18¾	16
	15 10 7½	29¼	16¾	14
Three	45 30	33	28¾	18
	15 9	29	22¼	14½
	6	23¼	17½	11½

- Emergency Overload Capacity
- Provides Long Lasting Economical Service
- Class B Insulation throughout
- Structural Steel welded construction
- Low-density Cores
- Multi-Cycle Vacuum-Impregnated Windings
- Lamination Interleaving
- Final Mica-Bond Emulsion Dip

"HUSH-FLUSH" transformers incorporate the same high standards of quality, material and workmanship that enable Precision to provide the industry's only

5-YEAR GUARANTEE

Write for information on PTC's Complete Line of Air-Cooled and Liquid-Filled Transformers

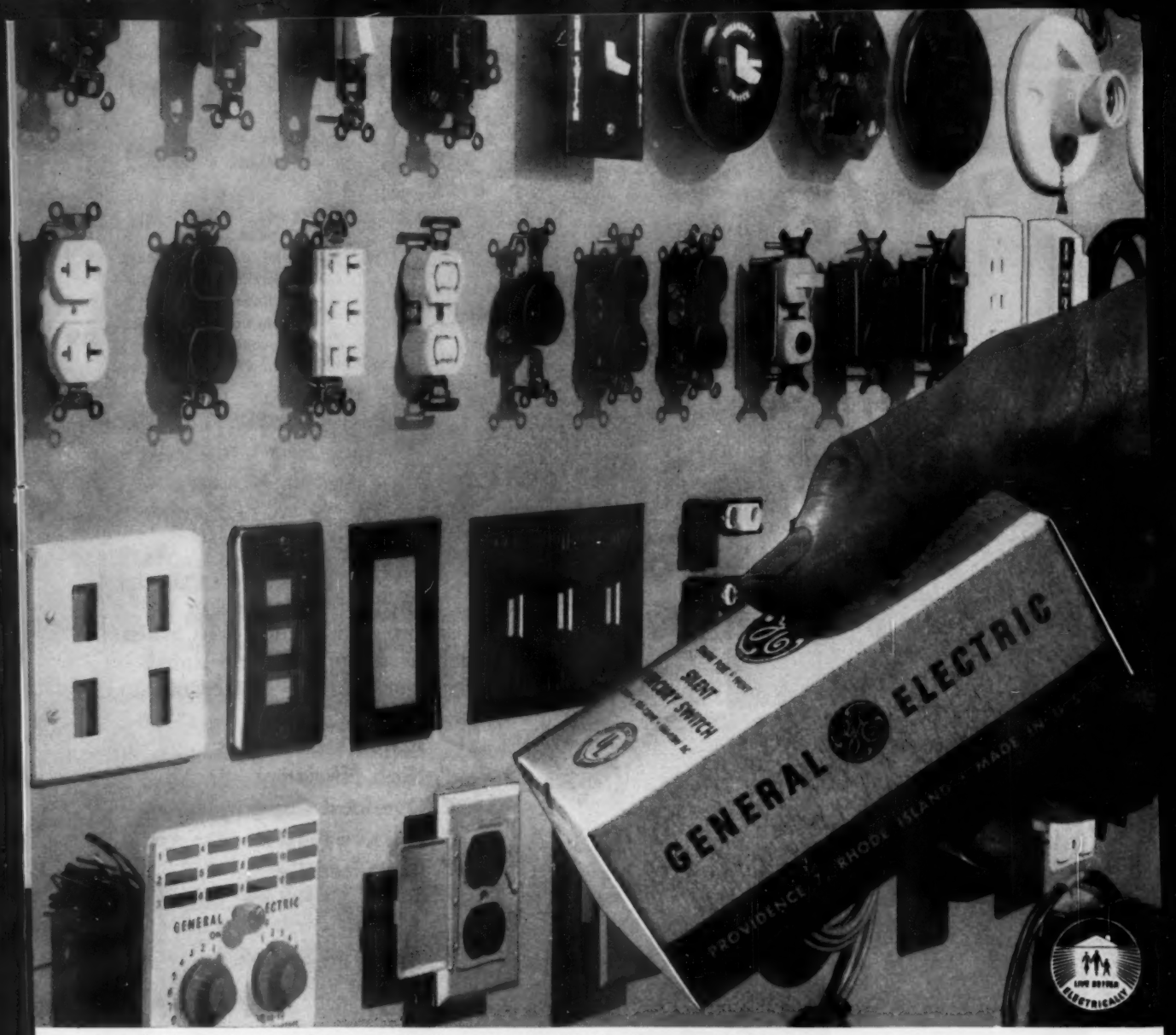
PTC TRANSFORMERS

PRECISION TRANSFORMER CORP.

DESIGNERS ENGINEERS MANUFACTURERS

2218 W. Lake Street • Chicago 12, Illinois

Representatives in all principal cities



In specification grade, intermediate grade, competitive grade, General Electric offers a complete line of up-to-date wiring devices.

New General Electric devices provide all the quality features that you appreciate

Call your General Electric distributor today!

Only General Electric gives you so many of the time savers and new ideas that you've been looking for, in a complete line of more than 1500 dependable, competitively-priced wiring devices.

You get easy-to-wire, screwless Pressure-Lock* terminals in many types of G-E wiring devices — with extra-large holes that accept two wires or a loop, for quick carry-through wiring — and a release mechanism that works easily.

You get long, 7/8" plaster-cleaning mounting screws, held captive in the strap; rigid "through" straps that hold alignment; shallow specification grade devices that leave more room for wires.

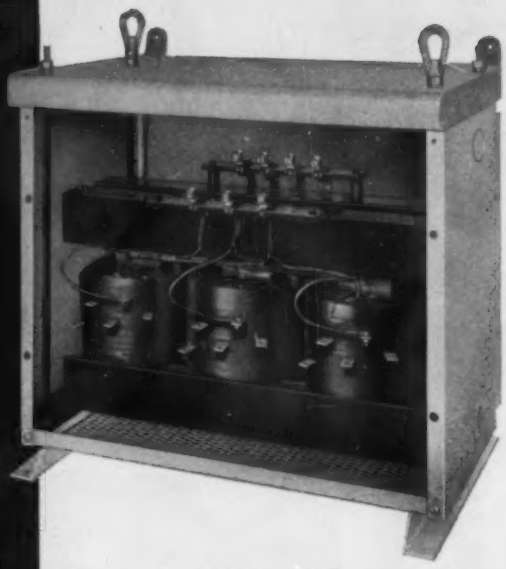
Your local General Electric distributor will welcome the opportunity to help you select the G-E wiring devices that are best for your particular needs . . . from the finest specification grades to the lower-cost competitive grades. General Electric Company, Wiring Device Department, Providence 7, Rhode Island.

*Trade-mark of General Electric Company

Progress Is Our Most Important Product

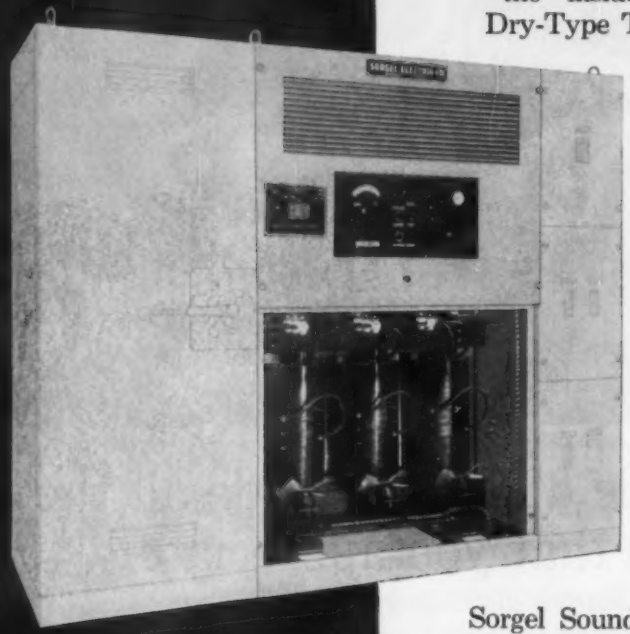
GENERAL ELECTRIC

it's an inside job!



45 Kva 3-phase transformer with taps. Interchangeable wall or floor mounting. Front panel removed, showing interior.

To be specific... it's the transformer, or the heart of the substation, that counts! Yes, when the "inside" includes a Sorgel Sound-Rated Dry-Type Transformer, you are assured of...



150/200 Kva 3-phase 4160 volt to 480 volt dry-type transformer with temperature control system

- **Extreme Quietness**
- **High Efficiency**
- **Overload Capacity**
- **Full Kva Plus**
- **Advanced Design**
- **Improved Safety and Protection**
- **Proved Reliability**

Leading the Industry with Over 40 Years of Manufacturing Development

Complete line for every purpose. Up to 10,000 kva, up to 15,000 volts. Also Special Transformers, Saturable Reactors, and Substations.

Sorgel Sound-Rated Dry-Type Transformers are the most practical to step down high distribution voltage to utilization voltage at load centers, in every type of building, and modernization projects.

SORGEL
SOUND-RATED DRY-TYPE
TRANSFORMERS

Sales Engineers in Principal Cities.

Consult the classified section of your phone directory or write to the factory.

Sorgel Electric Company

836 West National Avenue • Milwaukee 4, Wisconsin

FOR MORE INFORMATION ON

NEW PRODUCTS
CATALOGS, BULLETINS
ADVERTISEMENTS

USE THESE CARDS

- **PRODUCT NEWS, PRODUCT BRIEFS:**

  Use first line of boxes. Insert item numbers of products on which more information is desired.

- **CATALOGS, BULLETINS AND ENGINEERING DATA:**

  Use second line of boxes. Insert item numbers of literature desired.

- **ADVERTISEMENTS:**

  Use third line of boxes. Insert page numbers of advertisements on which additional information is desired. Where more than one advertisement appears on the page, include the manufacturer's initials.

IMPORTANT...

- PLEASE PRINT LEGIBLY
- USE BLACK OR DARK BLUE INK
- DO NOT USE PENCIL OR RUBBER STAMP

Please send me without obligation further information about the following: 5/59

Product News and Product Briefs, Item Number

Catalogs and Bulletins, Item Number

Advertisement on Page

NAME .....TITLE.....

COMPANY .....

ADDRESS .....

.....

ELECTRICAL CONSTRUCTION AND MAINTENANCE — A McGraw-Hill Publication

NOT GOOD AFTER JULY 1, 1959

Please send me without obligation further information about the following: 5/59

Product News and Product Briefs, Item Number

Catalogs and Bulletins, Item Number

Advertisement on Page

NAME .....TITLE.....

COMPANY .....

ADDRESS .....

.....

ELECTRICAL CONSTRUCTION AND MAINTENANCE — A McGraw-Hill Publication

NOT GOOD AFTER JULY 1, 1959

Your Name and address will be reproduced and sent to the appropriate manufacturers. Illegible or incomplete addresses may result in your not receiving the information you desire.

PLACE 3¢
STAMP
HERE

The Editor
ELECTRICAL CONSTRUCTION AND MAINTENANCE
330 West 42nd St.,
New York 36, N. Y.

PLACE 3¢
STAMP
HERE

The Editor
ELECTRICAL CONSTRUCTION AND MAINTENANCE
330 West 42nd St.,
New York 36, N. Y.

Your Name and address will be reproduced and sent to the appropriate manufacturers. Illegible or incomplete addresses may result in your not receiving the information you desire.

FOR MORE INFORMATION ON

NEW PRODUCTS
CATALOGS, BULLETINS
ADVERTISEMENTS

USE THESE CARDS

- **PRODUCT NEWS, PRODUCT BRIEFS:**
  Use first line of boxes. Insert item numbers of products on which more information is desired.
- **CATALOGS, BULLETINS AND ENGINEERING DATA:**
  Use second line of boxes. Insert item numbers of literature desired.
- **ADVERTISEMENTS:**
  Use third line of boxes. Insert page numbers of advertisements on which additional information is desired. Where more than one advertisement appears on the page, include the manufacturer's initials.

IMPORTANT...

- PLEASE PRINT LEGIBLY
- USE BLACK OR DARK BLUE INK
- DO NOT USE PENCIL OR RUBBER STAMP

Product News

Transformers (1)

A new line of 3-phase, general purpose transformers, type EPT, using thermosetting resin embedment is being manufactured in 9- and 15-kva ratings. The embedment material for the 3-phase type EPT, as in the single-phase type EP, is epoxy resin with electrical grade silica sand as filler. Chimneys through the resin material between the transformer components lessen the weight of the unit, permit the free flow of cooling air, and can be used for cable entrances. Also, the entire bottom of the transformer case is a terminal chamber with knockout for conduit entrance from three sides and the bottom. The 3-phase ratings now available are 9 and 15 kva in the 5000-volt class and below. All have brackets for wall mounting and are suitable for either indoor or outdoor installation.

Westinghouse Electric Corp., P. O. Box 2099, *Pittsburgh* 30, *Pa.*

Magnetic Clutch (2)

A stationary-field magnetic clutch has been added to this line. The new clutch series, designated EC-S, includes five sizes with torque ratings ranging from 14 through 290 lb-ft. The series will be expanded to include a total of 12 ratings by mid-1959. A primary advantage of new clutch is single-unit construction. Clutches are available for standard 24- or 90-volt dc operation. Literature is available.

I-T-E Circuit Breaker Co., 1900 *Hamilton St., Philadelphia* 30, *Pa.*

Variable-Speed Drive (3)

A shaft-mounted, mechanical variable-speed drive is now available. It has been designed for variable speed applications where space limitations dictate that the output shaft be at right angles to the transmission. It is especially adaptable to applications requiring controlled speed in a light-weight and compact power drive. Available in drip-proof or totally enclosed construction, these ¼ to 3 hp units feature speeds from 360 rpm to 5.2 rpm, and speed variations from 2:1 to 10:1. Speed-Trol Variable-Speed Drive Bulletin is available.

Sterling Electric Motors, Inc., 5401 *Telegraph Rd., Los Angeles* 22, *Calif.*

Plastic Conduit (4)

Conduit, manufactured from a new plastic material, is named DUR-X conduit. It can be assembled and laid by one person at the ditch in sizes up to 30 ft in length. Solvent welded connections are made at the site by applying a thin layer of cement with a brush. Each tier is laid separately, and a thin layer of cement poured over it. The plastic material is impervious to water. It is manufactured in 2-, 3- and 4-in. sizes.

Franklin Plastics, Inc., Franklin, Pa.

Lighting Unit (5)

A new area light, called Wide-Lite Juniors, is for use with 100-, 175- or 250-watt color-corrected mercury vapor lamps and 200-watt incandescent lamps. They are available with or without integrally-mounted ballasts. Units are used for local lighting in industrial plants, loading docks, service stations and for all types of protective lighting. The heavy-duty cast aluminum body of the unit is coated with epoxy-base aluminum paint for corrosion control. It is dust-proof and a special access plate permits easy relamping without disturbing the seal of the tempered, shock-resistant glass lens.

Wide-Lite Corp., Houston, Texas.

A PRODUCT OF STAMPINGS, INC.

THIS TRENCH IS COSTING ONLY 1 CENT PER FOOT

with the

POW-R-SPADE TRENCHER

Unsolicited performance reports from actual users state that POW-R-SPADE narrow trenches cost only 1 cent to 3 cents per foot, *including labor.* (Many report much less than 1 cent per foot.) Digging speed varies from 1½ ft. to 17 ft. per minute depending on soil conditions. POW-R-SPADE is light, rugged, with minimum of maintenance. Shipped *completely* assembled. Neat, fast, professional trenches—3 in. wide to 24 in. deep, or 4 in. wide to 18 in. deep Send coupon today.

One man can transport from job to job.

Stampings, Inc., 321½-24th St., Rock Island, Illinois
Please send material on POW-R-SPADE:

NAME _____

COMPANY _____

STREET _____

CITY _____ STATE _____

THREADS 1 TO 4-INCH PIPE WITH... NO DIE CHANGE!

Only BEAVER HAS IT!

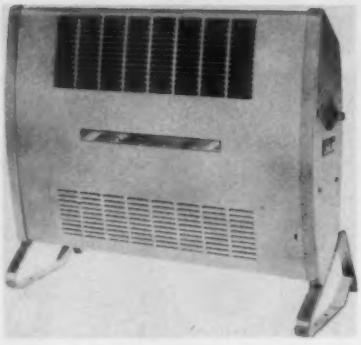
Only 980 lbs.!

BEAVER

Send for complete catalog and name of nearest distributor

PIPE TOOLS, INC.

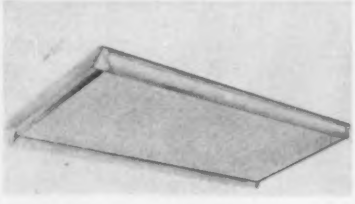
DANA AVE.
WARREN, OHIO



Electric Heater **(6)**

A new Chromalox electric convection heater, type DA, designed for floor or wall mounting. Case is made of aluminum, finished in grey hammertone enamel. All models come equipped with combination brackets for floor or wall mounting and a built-in three heat switch—120-volt model is available with 6-ft rubber covered cord and plug and is free-standing for portable use. Heating elements are all metal enclosed type. Model DA-15 is rated 1500 watts at 120 volts; DA-120 rated 2000 watts and DA-30 rated 3000 watts, both at 208 or 240 volts. All models are 21 ins. high and 8¾ ins. deep; DA-15 and 20 are 24¾ ins. long and DA-30 is 33¾ ins. long. Heater is for residential, commercial and industrial fields.

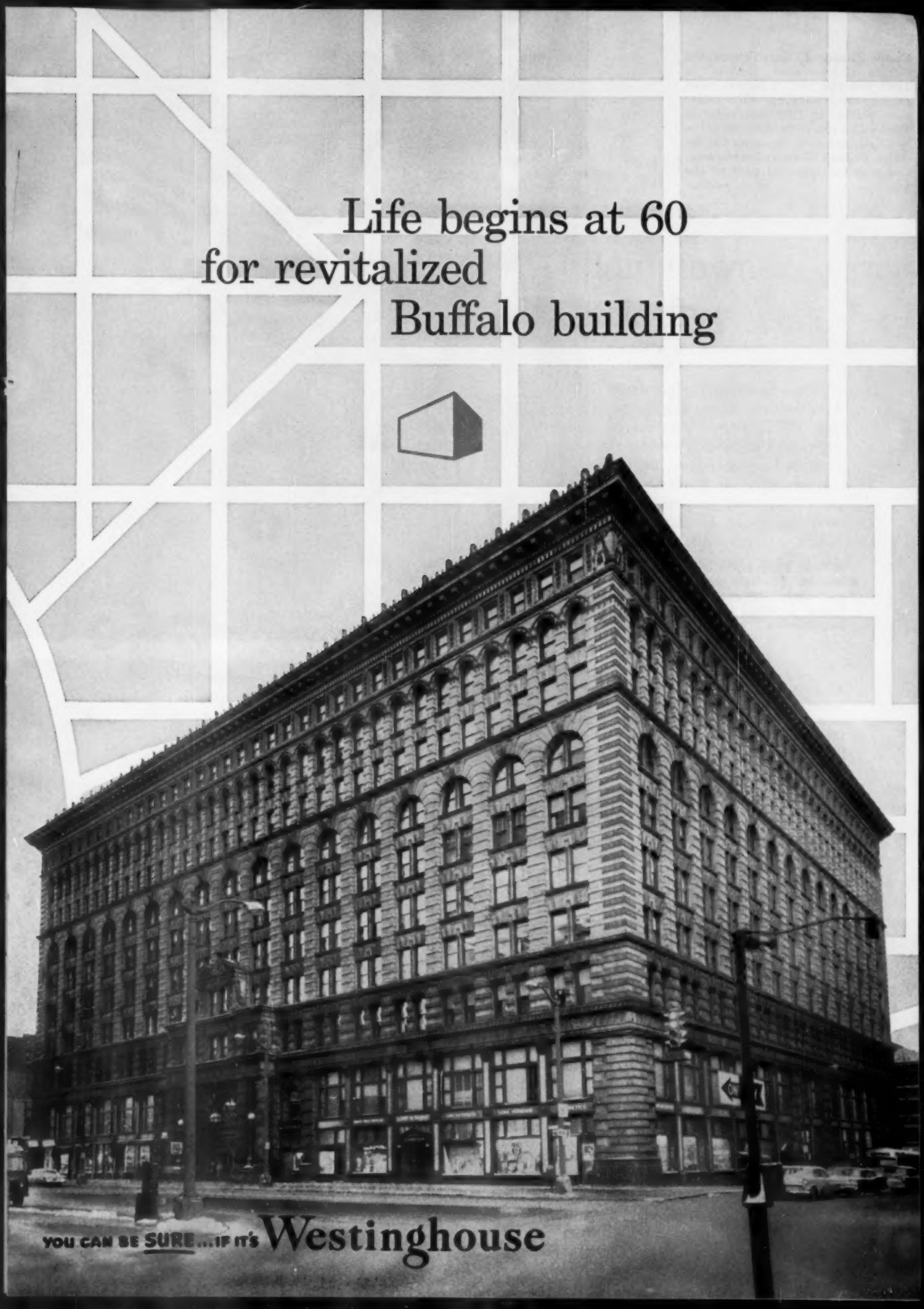
Edwin L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh 8, Pa.



Luminaire **(7)**

A new series of surface-mounted luminaires, called Sculpturama Visionaire, is for commercial use. Utilizing curved, low-brightness, illuminated metal side panels in combination with Sunlux plastic lens. Sculpturama No. 7500 Series is available for two or four rapid start lamp operation. Continuous row installation is achieved with use of a spacer connector. Various diffusers are provided with this luminaire for specific lighting requirements. All models in the series incorporate air space between the ballast mounting plate and ceiling, producing maximum thermal insulation.

Sunbeam Lighting Co., 777 E. 14th Place, Los Angeles 21, Calif.


Life begins at 60
for revitalized
Buffalo building
YOU CAN BE SURE...IF IT'S Westinghouse

Cover Photo: Ellicott Square, the "Pride of Downtown Buffalo" in 1895, was the world's largest, most modern office building. Modernization, started in 1958, continues in 1959 with a complete overhaul of the building including changing the facades. In 1958, electrical modernization was the essential part of the job. J-94102-2

Before: Main lobby before modernization. Elevator service was slow and costly. "Spotty" incandescent lamps provided low-level, uneven illumination.

After: Westinghouse *automatic* elevators are far faster, provide better service, and afford savings of more than $50,000 annually. New Westinghouse Mainliner fluorescent lighting gives even, attractive illumination, yet costs less per footcandle than the old incandescents.

Scene in one of the modernized office areas shows the new lighting with Westinghouse SC luminaires and a Westinghouse water cooler, foreground. Westinghouse lighting has been accepted as the building standard in remodeling the offices.

Electrical contractor helps building owner modernize for profits . . . electrically

Contractor-Owner-Westinghouse cooperation on 60-year-old Ellicott Square in downtown Buffalo paid off for *everyone*. And electrical contractors everywhere can use it as a superb example of how such modernization Builds Business Electrically . . . to build business for *you*, with your prospects. Here's the story:

In 1955, after years of service, the building had become a headache. Elevators were costly to operate. Old-fashioned incandescent lighting was dim, spotty . . . and costly. Antiquated power distribution equipment throughout the building was inadequate to carry the loads required for such modern necessities as business machines and air conditioning . . . and, under the inevitable overloads, costly to maintain.

What was the answer? Tear down the old and rebuild on this valuable site? A logical enough alternative. But, the decision: *Modernize* for profits . . . electrically.

After Buffalo Electric Co. submitted a survey of the building's electrical needs, the modernization program moved ahead rapidly. The electrical equipment order was placed in December, 1957, for delivery schedules to begin in February, 1958. Westinghouse carefully met the delivery dates, which enabled Buffalo Electric to complete the job on time without undue inconvenience or interruption of office services. Today, electric power is more than ample for all tenant needs . . . yet the building owner is saving substantially on maintenance and repair.

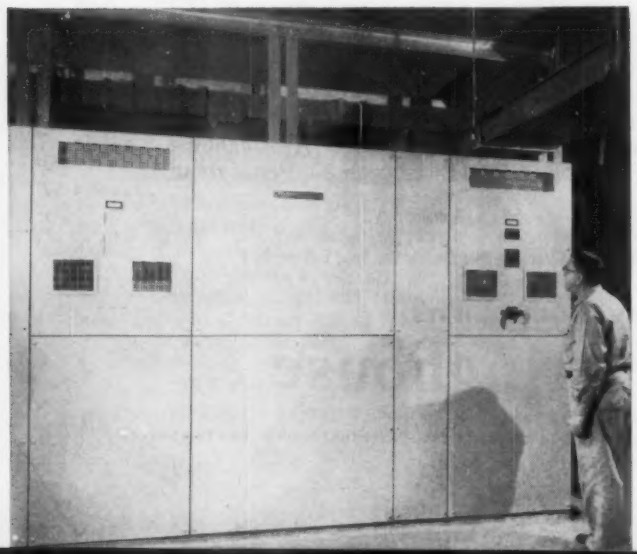
J-94102-3 (*cont.*)

YOU CAN BE SURE... IF IT'S

Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

H. Gilhooly inspects new Westinghouse building-type switchboard which houses a DB-100 main circuit breaker for incoming power. Westinghouse low-impedance, 4000-amp bus duct connects new receiving switchgear with modernized main distribution switchboard. Note provision made at left for addition of future breakers when needed.



Maximum short circuit kva available from the power company network loop made many existing circuit breakers in this old switchboard inadequate. Edwin Loth, Building Superintendent, right, learns from H. Gilhooly how new Westinghouse Tri-Pac* breakers will protect against any fault conditions possible in the system. Westinghouse Tri-Pac breakers can protect against fault conditions up to 100,000 amps, asymmetrical. *Trade-Mark

Karr Parker, Jr., Buffalo Electric Co., Electrical Contractors; Daniel F. Hannon, Jr., Building Manager, Ellicott Square; and Charles T. Hansen, Westinghouse Sales Engineer, examine building plans in new power machine room now made possible by modernization of electrical system. Excellent cooperation and planning among Ellicott Square management, Buffalo Electric and Westinghouse brought about job completion without undue inconvenience to tenants or interruption of building services.

Ed Loth inspecting a Westinghouse NPLAB panelboard installed in electrical closets on each floor, one of 46 panels throughout the building. AB-I circuit breaker, shown at right, serves as the main breaker on the floor.

(cont.)

Life begins at 60 . . . thanks to electrical modernization

Best of all, these modern improvements have made this historic building once more a *prestige* location. Leased office space is up . . . and tenants are willing to pay *more* for it. In 1957, a unit of space rented for $186 monthly . . . in 1959, it brings $207 . . . an increase of 11.1%. And it's *worth* it to the tenants . . . because such modernization of surroundings makes employes far more efficient.

For some eye-opening data on how modernization can help you Build Business Electrically, call your Westinghouse distribution outlet, or write: Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pennsylvania.

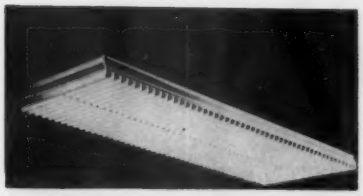
J-94102-4

Owner: Ellicott Management Co., Buffalo, N. Y.
Electrical Contractor: Buffalo Electric Co., Inc., Buffalo, N. Y.
Westinghouse Distributor: Buffalo Electric Co., Inc., Buffalo, N. Y.

YOU CAN BE SURE...IF IT'S

Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS



Luminaire **(8)**

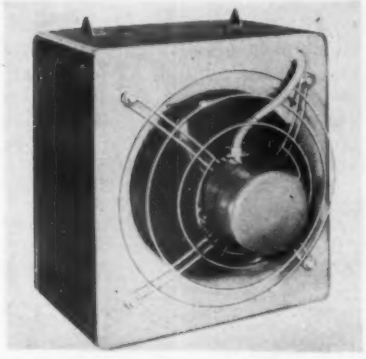
A new luminaire designed for commercial application of Power Groove lamps is called the "Power-Lux." Controlled brightness is achieved through the use of parabolic louvers. Two-lamp models, 12 ins. wide, and 4-lamp models, 36 ins. wide, are available in 4- and 8-ft lengths.

Lighting Products Inc., Highland Park, Ill.

Fittings **(9)**

A complete series of flush switch fittings, known as "FS" and "FD". They are available in single through 5-gang styles, all with convenient mounting lugs. A full range of hub arrangements and conduit sizes are available. They are made of cast aluminum for light, non-rusting, non-corroding service.

Killark Electric Mfg. Co., Vandeventer and Easton, St. Louis 13, *Mo.*



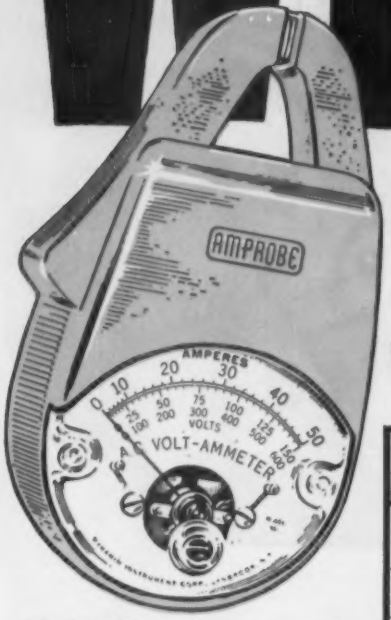
Electric Heaters **(10)**

Seven newly designed electric unit heaters increasing capacity in its line from 7½ kw to 36 kw have been announced. Units feature black-heat type elements which are individually replaceable, new safety design which eliminates bare wires and terminals in the air stream and totally enclosed motor with quiet "Q" type fan wheel. Units are designed for office, store and industrial use and cover a heating range to 122,832 Btu. Bulletin 808 is available.

Ilg Electric Ventilating Co., 2850 *N. Pulaski Road, Chicago* 41, *Ill.*

SABER-TOOTH
DRILL-N-ANCHOR
fastest
way to
fasten to
concrete
It's a drill...and drills its own hole fast, even in hard concrete, with power-operated or hand hammer. Saber-Tooth's core action drills quickly. Drill and anchor are one...matching sizes is no problem. Save the cost of special drills, the time it takes to use, store and sharpen them.
It's an anchor...and holds fast: engineering tests demonstrate holding power up to 17,860 lbs. As you drive it into hole, anchor expands over plug...holding ridges around body resist pull-out. Saber-Tooth anchor withstands severe shock and vibration...double plating protects against rust, corrosion.
Put steel expander plug in drill end of Saber-Tooth, drive home... anchor expands over plug, at bottom of hole for greatest holding power.
THE RAWLPLUG COMPANY, INC.
212 Petersville Road New Rochelle, N.Y.
Please rush my Saber-Tooth sample and complete facts.
Name
Firm
Address
R4

WHY settle for an ordinary voltage tester?



The AMPROBE Jr. gives you so much more... not just a run-of-the-mill voltage tester but a precision-made instrument that measures voltage *and* current instantly and accurately without shutting down equipment. All this with one rugged and inexpensive pocket-size tool! And now...FOR THE FIRST TIME...at the request of utilities, industrial plants and other large-scale users of AMPROBES, the AMPROBE Jr. has gone SAFETY YELLOW to conform with standard safety practices.

Ask yourself these questions	The AMPROBE Junior	ordinary voltage tester
Does it measure current as well as voltage?	YES	NO
Does it give you full visibility on a graduated reading scale?	YES	NO
Does it fit conveniently in your pocket?	YES	YES
Does it measure within ±3% accuracy?	YES	NO
Does it come in a full line of models to meet different problems?	YES	NO
Does it protect you against shorts and shocks?	YES	YES
Does it balance loads, locate grounds, determine motor overloads, check rating of circuit breakers?	YES	NO

PICK THE AMPROBE *YOU* NEED! There's an Amprobe for every job, every budget: from 10 amps and 250 volts to 1200 amps and 600 volts AC; from $19.85 to $67.50. And with the Amprobe RS-3, you get a volt-amp-*ohmmeter* all in one pocket-sized, snap-around precision instrument. Every Amprobe comes with test leads; most with top grain cowhide leather case at no extra cost. See the complete Amprobe line at your jobber's today.

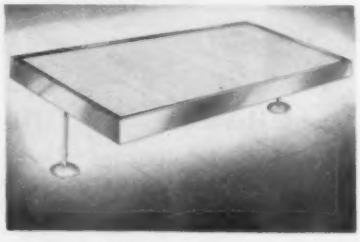
Amprobe Jr.®
snap-around volt-amp tester
$19.85

PYRAMID INSTRUMENT CORP., Lynbrook, New York

Transformers **(11)**

A new line of general purpose dry-type transformers for commercial and industrial applications, known as the QHT (Quiet, High Temperature) line. The transformers have newly developed silicone impregnated insulation, aluminum windings, interleaved steel core and laminations of cold-rolled silicon, grain-oriented steel for lighter weight and efficient operation. Available in three types: B (80°C rise, 25va through 3 kva, single-phase); F (120°C rise, 5 through 25 kva, single-phase and 3 through 15 kva, 3-phase); and H (150°C rise, 30 kva and above, single and 3-phase). Units have large terminal compartments, wiring spaces and accessible connections; those 30 kva and up have rubber "isolation" pads between case and core and coil assemblies. All have easy-to-install mounting and lifting accessories. Standard distribution voltages are 600, 480 and 240; load voltages, 480, 240 and 120.

General Electric Company, Schenectady 5, N. Y.



Lighting Fixture **(12)**

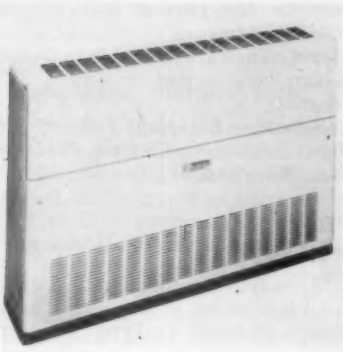
A newly developed SDLO series of semi-indirect, low-maintenance open-top fluorescent fixtures has been announced. This series comes in 24-, 48-, 72- and 96-in. lengths; available in 2-, 3- and 4-lamp, rapid start and slimline. They can be installed either singly or in rows.

Leadlight Fixture Co., 800-100th Ave., Oakland, Calif.

Motors (13)

A new line of dc motors, called Flexitorq, are available in ratings of 1 to 200 hp, in drip-proof and drip-proof guarded enclosures. They are designed to supply constant or adjustable speed for driving machine tools, metal rolling, drawing or forming machines, cranes, hoists, conveyors, etc. A new Class B insulation is used throughout, permitting intermittent high overloads. The new line also includes Flexitorq generators in ratings of ¾ to 170 kw. Bulletin 3150 is available.

Louis Allis Co., Milwaukee 1, *Wis.*



Heaters (14)

A new line of electric cabinet heaters including two blow-through units with direct-drive fan assemblies and a draw through model with V-belt-driven fan assembly. Units are available for floor, ceiling, wall or inverted mounting, and can be non-recessed, semi-recessed or concealed as desired. Units feature non-glowing finned strip elements individually housed in steel closers. Wiring is enclosed in flexible metallic conduit throughout. Three types of control are available with the new Series AE heaters: manual, pneumatic and automatic heaters. Bulletin 1801 is available.

Ilg Electric Ventilating Co., 2850 *N. Pulaski Road, Chicago* 41, *Ill.*

Capacitor (15)

A new 5-kv, 3-phase, 100-kvar capacitor to improve power factor, relieve overhead transmission lines and improve voltage level. Since the 100-kvar, 3-phase capacitor can be applied with single-crossarm, double-crossarm, or direct pole-mounting bracket, 3-phase primary banks can be furnished with 3-phase 4160-volt units using simple-mounting supports.

Westinghouse Electric Corp., P. O. Box 2099, *Pittsburgh* 30, *Pa.*

THIS IS *Practical* MAINTENANCE

...WITH *Servisafe* BRACKET UNITS!

Servicing wall or pole-mounted luminaires *at ground level* is the most practical method because it is the safest, fastest and most economical. With "Servisafe" Bracket Units, one man can relamp and clean luminaires within minutes in any kind of weather. There are no climbing or electrical dangers. And no costly auxiliary equipment is required.

"Servisafe" Bracket Units can be used for new installations or quick conversion of existing facilities. Supplied as complete packages ready for wiring and erecting, they can be mounted on walls, wood poles and other structures to provide year-round lighting efficiency with minimum maintenance cost.

8487-TE

FOR DETAILS AND SPECIFICATIONS, WRITE FOR BROCHURE PWB-59.

THE THOMPSON ELECTRIC CO.

P. O. BOX 873-D, CLEVELAND 22, OHIO

CONTINENTAL ASBESTOS-INSULATED
POWER CABLE

***TYPE AVA TO 5000 VOLT SERVICE** available sizes: 14 AWG to 1,000,000 CM inclusive. Conforms to N.E. code standard and NEMA standard WC1-1955 and ASA C8.-36-1955.*

Engineered insulated wire and cable from Continental Wire assures maximum Job-Dependability.

Type AVA Power Cable is recommended for use in open or in conduit installations where advantages of excellent current carrying capacity and resistance to high temperature are desired . . . and where operating conditions include oil, grease, corrosive vapors or moisture.

There's a complete line of Continental Insulated Power Cable in sizes 14 AWG to 1,000,000 CM inclusive . . . insulation types include AVA . . . AIA . . . V . . . AVB . . . Silicone Rubber . . . Glass . . . Teflon Tape . . . and Varnished Glass Tape.

For more information write Continental, Wallingford.

continental wire *corporation*

WALLINGFORD, CONNECTICUT • YORK, PENNSYLVANIA

Fluorescent Fixture (16)

A new series of fluorescent lighting fixtures designed for pendant or close-ceiling suspension and also suitable for surface mounting, called the "Classic" line. The fixtures, 3⅞ ins. deep, are particularly suitable for general and private offices, conference rooms, and retail stores. They are available in 2- and 4-lamp models and in 4- and 8-ft lengths.

Sylvania Lighting Products, a div. of Sylvania Electric Products Inc., Wheeling, W. Va.

Sign Light (17)

Glare-free sign illumination without obstruction of the sign's message is provided by Type SFL sign light, available in 10-in. and 12-in. sizes. It may be used above, below or on corner of sign. A number of different reflector and lens combinations are offered. Lamps used include 150-, 200- or 300-watt incandescent and 175- or 250-watt mercury. White baked enamel is standard exterior finish for reflector and housing, but any color can be supplied on request. Literature is available.

Crouse-Hinds Co., Syracuse 1, N. Y.

Photorelay (18)

An electric eye housed in a weathertight and shock-resistant enclosure is now available. Mounted in a Crouse-Hinds FD-1 Condulet box with a ½-in. threaded fitting, this light sensing control withstands the effects of dust, moisture, shock, vibration and other adverse conditions. Using a solid-state photocell, the Model R-CH photorelay automatically triggers on-off and go-no-go circuits at predetermined light levels. It is sensitive to 10 fc. It operates on 60 cycles, 115 volts ac. It uses single-pole, single-throw relay contacts rated at 5 amps at 115 volts ac. It may be used in any position.

Berkeley/Dynamics, 2831-7th St., Berkeley, Calif.

Circuit Breaker (19)

A remote, solenoid-operated circuit breaker, electrically operated and mechanically held, is for use with a variety of automatic controls for multiple-circuit, mixed-load service. Capacities are 0-50 and 50-100 amp at 240-volt, 480-volt, ac, 125- and 250-volt dc, with interrupting capacities rated at up to 10,000-amp rms. Unit can be provided for either automatic or manual reset when breaker is tripped due to overload or short circuit. The solenoids which open and close breaker are available for use with all voltages, ac or dc.

Lake Shore Electric Corp., Bedford, Ohio.

Telescoping Platform Lift (20)

The Sky-Liner is a mobile battery operated rotating platform lift for high reach and ceiling maintenance work. Raising to a maximum height of 15 ft, it is capable of making a complete 360° turn, extends 6 ft 6 ins. Platform and unit is motivated by a 24-volt battery through pushbutton control. Unit features a self-contained water system with a three compartment sink on the platform. A 30-gal tank is located in the base of unit. Platform also has electrical outlets for use of power tools and equipment.

Grand Specialties Co., 3101 *W. Grand Ave., Chicago* 33, *Ill.*

Carbon Brush (21)

A new improved Red Top carbon brush has been introduced. The glastic top surface of the new Red Top section resists any spring finger indentation or wear and the neoprene pad combined with it absorbs vibration and shock. Bulletins are available.

Helwig Co., 2554 *N.* 30*th St., Milwaukee* 10, *Wis.*

Clamp (22)

A screwless "Q" Quick-Clamp for outlet and switch boxes has been added to the RACO line. Non-metallic sheathed cable is gripped firmly as soon as it is shoved through the Quick-Clamp. It operates on a principle that permits the cable to easily pass through the clamp in one direction only. When cable is pulled in other direction, clamp tightens and prevents movement.

All-Steel Equipment Inc., Aurora, Ill.

NEW! 2-WAY

control versatility

REMOTE SWITCHING...PLUS OVERLOAD...AND SHORT CIRCUIT PROTECTION

SOLENOID OPERATED BREAKER

Compact...Low-Cost...Simplified Circuitry

Here's the answer to sure, low-cost remote panelboard control for lighting and branch distribution circuits... for limited service starters and contactors. Choice of signal?... timer, automatic, pushbutton.

Electrically-operated dual-solenoid actuators. Mechanically-held for failure-proof service with standard breakers. Protection includes thermal overload and short circuit. Trip-free design.

Interrupting capacities to 10,000 amp rms!

2 pole – 3 pole – 4 pole

240 – 480 – 600V AC
125 and 250V DC

State control voltage and current ratings when requesting quotations.

THE Lake Shore ELECTRIC CORPORATION

205 Willis Street BEDFORD, OHIO

For General Use buy RIDGID Heavy-Duty Pipe Cutters

Factory tested for perfect tracking, here's your best cutter buy for hand use. Extra-long shank protects threads, gives fast, easy adjustment. Large handle for sure grip . . . more leverage. Strong, special malleable frame won't bend or warp. You'll also need the RIDGID Wide-Roll Cutter, that tracks perfectly at high power-drive speeds, and the RIDGID 4-Wheel Cutters, that give quick, clean cuts in tight places with only quarter turns.

For Tubing and Thin-Wall Conduit buy RIDGID Tubing Cutters

Exclusive fold-in reamer on Nos. 10, 15 and 20 protects hands and pockets . . . reams full cutter capacity. Thin-blade wheel gives quick, clean cuts. Rollers smooth tubing ready for soldering. Special RIDGID No. 315 3-Wheel Cutter gives fast cuts in hard-to-get-at places.

There's a RIDGID Cutter to save you time on every job. Call your Supply House today!

RIDGID

The Ridge Tool Company, Elyria, Ohio, U.S.A.

Pushbutton Enclosures (23)

A new complete line of Boss pushbutton enclosures, designed for use with all standard makes of oil-tight pushbuttons, switches and pilot lights, especially where protection is needed against oil, dirt and other liquids. Included in the line are 38 different enclosures with four types available: standard, extra deep, slim and pendant. All are constructed of 14 gauge steel. They can be mounted either vertical or horizontal, and are manufactured to JIC, NEMA, and UL standards for industrial control equipment. Literature is available.

Huenefeld Company, Engineering Products Div., 2701 Spring Grove Ave., Cincinnati 25, Ohio.

Cable Clamp (24)

A newly developed MIF spacer type aerial cable clamp is available in two sizes, providing a messenger diameter range from $\frac{1}{16}$-in. to $\frac{5}{8}$-in. Clamp assembly consists of a pole plate spacer unit which permits attaching the messenger and cable spacer $4\frac{1}{2}$ ins. and $9\frac{1}{2}$ ins. respectively from pole surface. A curved pole contacting surface of large area provides stability of spacer unit when mounted on pole. An extra groove is cast into spacer body to accommodate an optional pole ground wire. Literature is available.

Malleable Iron Fittings Co., Branford, Conn.

Product Briefs

(25) Three new U-shaped ground **receptacles** in two electrical ratings have been made available by the Pyle-National Company, Chicago, Ill., for use with FS and FD series Pylet boxes. . . . (26) Davis Scaffold Company, Lannon, Wis., has announced a new **scaffolding,** featuring 3-piece "unit" construction that consists of two end-frames and a one-piece platform. . . . (27) A double **ground tap** that converts standard receptacles to safe grounded outlets has been developed by Eagle Electric Mfg., Co., Inc., Long Island City, N. Y.

(28) Kato Engineering Company, Mankato, Minn., has announced that the dc **generator** line is now available in sizes ranging from 500 watts to 40 kw with various voltages throughout the line. . . . (29) A new telescoping work **platform,** known as "Elevator-Size Tallescope," is made of aluminum

and fits inside any normal size elevator or storage closet and rolls through doorways. It is manufactured by Up-Right Scaffolds, Berkeley, Calif. . . . (30) Markstone Mfg. Co., Chicago, Ill., has introduced a new series of **square incandescents** for 2-, 3- and 4-lamp interior applications.

(31) Electro-Sheave, a combined electric **clutch** and **sheave** assembly for direct installation on all standard NEMA electric motor shafts, has been announced by the Warner Electric Brake & Clutch Co., Beloit, Wis. . . . (32) A complete line of UL-approved Plasticord flexible service **cords** is now available from Chester Cable Corp., Chester, N. Y. . . . (33) A new, lightweight **lamp-puller** designed for porcelain-base incandescents, has been developed by Marsto Machine Co., Inc., Quincy, Mass.

(34) A new heavy-duty **router-plane kit** has been introduced by Black & Decker Mfg. Co., Towson, Md. It combines the versatile power of the 1-hp heavy-duty router with the all-new power plane attachment. . . . (35) Availability of a probe type liquid level **controller** has been announced by Cutler-Hammer Inc., Milwaukee, Wis. . . . (36) New high slip, crane-hoist duty **motors** have been introduced by Reuland Electric Co., Alhambra, Calif.

(37) The U.S. Expansion Bolt Co., York, Pa., has introduced a new masonry hand **fastening system** known as the "Multi-Use" fastening system. . . . (38) A new **earth boring machine** and **pole setter** designed to handle the 100-ft Class A poles, has been announced by Calavar Corp., 2700 S. Broadway, Los Angeles, Calif. . . . (39) A new ½-in. drive heavy duty electric **Impactool** has been developed by Ingersoll-Rand, 11 Broadway, New York 4, N. Y.

(40) Completely zinc coated threads on pipe and couplings, plus an overall coating of zinc bichromate are two new features of the hot-dip galvanized rigid steel **conduit** produced by Triangle Conduit & Cable Co., Inc., New Brunswick, N. J. . . . (41) A new Model 458 magnetic **tape reproducer** equipped with automatic program inter-mixer and automatic control for playing and non-playing time intervals has been announced by AltoFonic Corp., Palo Alto, Calif.

To save time . . .
Every Tool Box Needs
a compact, easy-to-carry

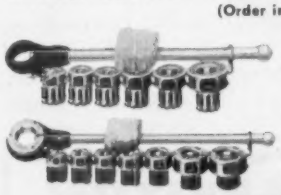
RIDGID®

Drop Head Threader Set

Snap a die head in the ratchet ring . . . cut your thread! It's as simple as that with a RIDGID drop head threader. Heads can't fall out . . . dies reverse quickly for close-to-wall threading. Finest quality RIDGID long wearing dies. Bolt and conduit dies available.

Call Your Supply House!

Hand Carrier Free With All Sets Except No. 12-R
(Order in sets or any combination)



Exposed Ratchet Type
For pipe: ⅛" to 1"—00-R; ⅛" to 1¼"—111-R; ⅛" to 2"—12-R
For bolts: ¼" to 1"—00-RB

Enclosed Ratchet Type
For pipe: ⅛" to 1"—0-R; ⅛" to 1¼"—11-R

RIDGID
The Ridge Tool Company, Elyria, Ohio, U.S.A.

Building: 2 Broadway, N.Y.C.—30 story and penthouse
Owner and General Contractor: Uris Brothers
Architect: Emery Roth & Sons
Electrical Engineer: Alfred J. Kleinberger
Electrical Contractor: Fischbach & Moore, Inc.
LEVITON
#5521 QUIET SWITCHES
A full line of 15A and Heavy Duty 20A AC Quiet Switches

IN IMPORTANT STRUCTURES EVERYWHERE . . .

SPECIFICATION GRADE

LEVITON

Wiring Devices

ARCHITECTS, ELECTRICAL ENGINEERS, ELECTRICAL CONTRACTORS everywhere specify Leviton. You, too, can take advantage of Leviton's complete line of Specification Grade wiring devices. Investigate this comprehensive line yourself! Sold thru authorized electrical distributors.

FOR FULL INFORMATION AND CATALOG WRITE TO:

LEVITON

LEVITON MANUFACTURING COMPANY • BROOKLYN 22, N. Y.

Chicago • Los Angeles • Leviton (Canada) Limited, Montreal

For your wire needs, contact our subsidiary: AMERICAN INSULATED WIRE CORPORATION

Catalogs & Bulletins

(42) SERVICE EQUIPMENT. New Speedfax catalog covers complete line of fusible and circuit breaker service entrance equipment, including raintight boxes, 60-, 100- and 200-amp ratings, series- or parallel-connected. Walker Electrical Co., Inc.

(43) ADJUSTABLE SPEED DRIVE in ratings of ¾ to 7½ hp for machine tools, process machinery, printing presses and similar equipment is described in bulletin 2750, 6 pages. Louis Allis Co.

(44) ELECTRIC HEATERS. New 16-page bulletin F-975C illustrates complete line of Chromalox comfort heaters for residential, commercial and industrial applications, including convection, forced-air and radiant models. Edwin L. Wiegand Co.

(45) PHASE-ISOLATED TRANSFORMERS. 20-page booklet 591 covers applications and advantages of load tap changing transformers which provide separate and individually controlled voltage regulation for each phase. Pennsylvania Transformer Div., McGraw-Edison Co.

(46) SOLENOID VALVES. New catalog 444 lists complete line of over 200 valves of bronze and stainless steel construction, giving detailed specifications and performance data. Atkomatic Valve Co.

(47) ADJUSTABLE SPEED DRIVE equipment for industrial applications where accurate speed control is essential is described in new bulletin GB-3. Dynamatic Div., Eaton Mfg. Co.

(48) DEFLECTION FITTINGS for providing ¾-in. expansion and contraction and a 30-degree angular movement in any direction when used with threaded rigid conduit from ½ to 4 in. Spring City Electrical Mfg. Co.

(49) ELECTRIC HEATERS. Two blow-through and one draw-through cabinet units are described in bulletin 1801. Ilg Electric Ventilating Co.

(50) MULTI-CONDUCTOR CABLE for installing 6 to 56 pairs of thermocouple loads at one time from a number of measuring points to indicators, recorders or controllers is covered in catalog 33. Thermo Electrice Co., Inc.

(51) RECTIFICATION EQUIPMENT is included in new 68-page catalog 591 along with vibrators, car shakers, and other equipment. Syntron Co.

(52) CONDULETS for corrosive locations plus listings of Plast-A-Coat fittings for hazardous and non-hazardous locations are listed with application charts in new 16-page bulletin 2699. Crouse-Hinds Co.

(53) SNOW MELTING of driveways is described for home-owners in a new self-mailer titled "The Invisible Snow Shovel" which electrical contractors may mail to their customers and to prospective home owners. General Electric Co.

(54) MAINTENANCE EQUIPMENT including high-speed rotary files, mica undercutters, field coil testers, portable blowers, and over 100 other products are detailed in new catalog 32. Martindale Electric Co.

(55) HEADERDUCT components for coordination with cellular floor construction for electrical and communication wiring are covered in new bulletin 490 with detail drawings, dimensions and identifying numbers. National Supply Co.

(56) PUBLIC ADDRESS SYSTEMS, speakers and components with full information, illustrations and specifications are treated in new product catalog. University Loudspeakers, Inc.

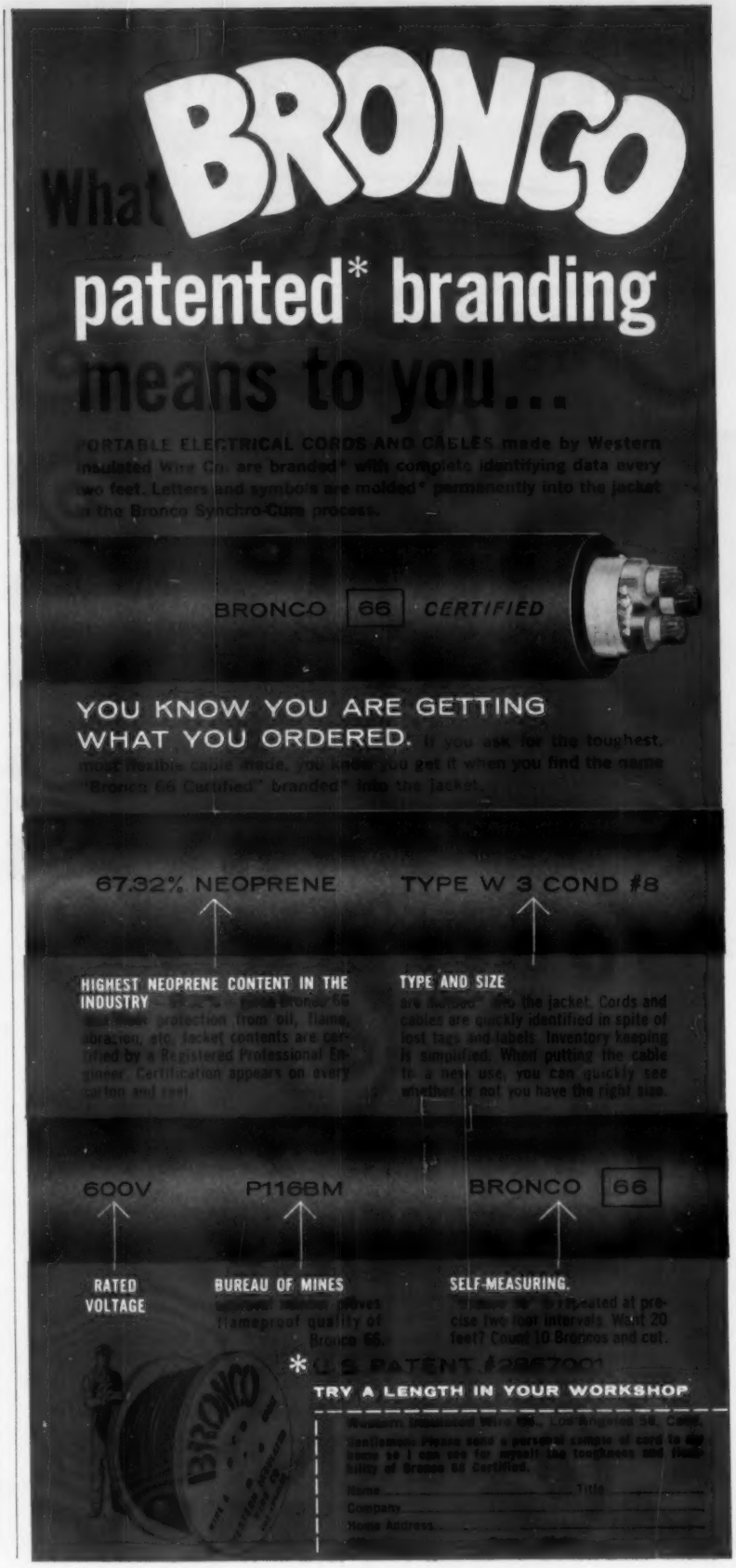
(57) INSTRUMENT RENTAL. 8-page bulletin GEA-6829 describes new nation-wide instrument rental program established through network of service shops involving more than 13,000 electrical instruments. General Electric Co.

(58) ELECTRIC PLANTS for generating electricity for light and power. Large fold-out sheet presents complete information on selection of gasoline- and diesel-powered units, battery-charging models, and marine-type electric plants. Universal Motor Co.

(59) RELAYS ranging from small multi-contact midgets to sensitive, heavy duty and power types are featured in new 16-page catalog. Guardian Electric Mfg. Co.

(60) INDUSTRIAL TRUCKS. 12-page condensed catalog classifies six categories: fork trucks, heavy-duty fork and ram trucks, low lift platform trucks, high lift platform trucks, die handling trucks, and cranes. Elwell-Parker Electric Co.

(61) ELECTROLUMINESCENCE. New booklet describes Rayescent readout lamps using phenomenon of electroluminescence with almost negligible current drain for the display of luminous letters and numerals in various types of dials. Westinghouse Electric Corp.



CLAYTON MARK
ELECTRICAL CONDUIT

The Washington National Insurance Co. building at Evanston, Ill. used MARK Conduit
MARK Conduit used in Marshall Field's Old Orchard Shopping Center
MARK Conduit being installed in the New Trier High School, Winnetka, Ill.
Clayton Mark & Company's three brands of rigid steel conduit and "Electrictube" thinwall conduit are inspected and approved by Underwriters' Laboratories. The high quality, durable and easy-working characteristics have made MARK rigid and thinwall conduit "The Contractor's Favorite" for almost a half a century.
GALVAKOTE
ENAMELKOTE
KOTKOTE
ELECTRICTUBE

AVAILABLE EVERYWHERE TO SERVE YOU!

Associated Agencies, Inc.
Boston 20, Massachusetts

Brazill Brothers
Linden, New Jersey

Cary Chapman & Company
New Orleans, Louisiana

Cary Chapman & Company
Greensboro, North Carolina

Cary Chapman & Company
Atlanta, Georgia

Cary Chapman & Company
Hialeah, Florida

Cary Chapman & Company
Birmingham, Alabama

A. Lee Clifford & Company
Indianapolis 7, Indiana

Crescent Electric Sales Co.
Chicago 47, Illinois

Eberhardt Electric Sales Co.
Buffalo 11, New York

Electric Agencies
Seattle 4, Washington

Hodges & Glomb, Inc.
San Francisco 3, California

M. J. Pelletier Company
Minneapolis 1, Minnesota

Popkin Brothers
Cincinnati, Ohio

Popkin Brothers
Cleveland 14, Ohio

Popkin Brothers
Detroit 1, Michigan

Popkin Brothers
Toledo, Ohio

Jim Randall Company
Dallas, Texas

Rutkin Electrical Sales Co.
Los Angeles 21, California

The Schooler-Gorman Co.
Kansas City 1, Missouri

Wm. C. Welde & Sons
Philadelphia 4, Pa.

Randolph C. Wohltman Co.
St. Louis 10, Missouri

W. E. Young Company
Denver 5, Colorado

Since 1888, quality products for home and farm

CLAYTON MARK & COMPANY

1900 Dempster Avenue • Evanston, Ill.

(62) LIGHTNING ARRESTERS and primary protective gaps are described in bulletin LA6, including complete descriptions, application data and ordering information. Line Material Industries.

(63) ELECTRIC HEATING CONTROLS. Brochure R-1625, 4 pages, covers complete line, including both wall- and integrally-mounted, with drawings showing wiring and operating principles. White-Rodgers Co.

(64) ELECTRIC UNIT HEATERS. Complete specifications and construction information on entire line covering 14 models from 1½ to 36 kw are presented in new 4-page bulletin 808. Ilg Electric Ventilating Co.

(65) METAL POLES and wall bracket units for outdoor lighting applications incorporating Servisafe disconnecting and lowering mechanism are described in brochure PWB-59. Thompson Electric Co.

(66) MOTOR STARTERS, components and accessories including glass-filled, thermal set mold-type contact block, molded epoxy and dual voltage magnet coils, overload relays, and contacts are covered in new bulletin 14B9182. Allis-Chalmers Mfg. Co.

(67) DRY-TYPE TRANSFORMERS and saturable reactors are covered in two new bulletins, 958 and 658, respectively. Transformers are rated ¼ to 10,000 kva, single and 3 phase, 120 to 15,000 volts. Reactors described include 15- and 25-kva single-phase models as well as 150- and 470-kva 3-phase models. Sorgel Electric Co.

(68) PHASE FAILURE RELAYS. 4-page bulletin 230 describes a phase-voltage-balance device for use with magnetic controls to automatically prevent three-phase motors or equipment from operating under open-phase or single-phase conditions. Phase-Guard Co.

(69) DISTRIBUTION DEVICES. 84-page Buy Log (Cat. GEC-1100) presents condensed application, selection, pricing and ordering information on circuit breaker load centers, fuse puller panels, safety switches, wire-way, molded-case circuit breakers and enclosures, lighting panelboards, distribution panelboards and busway. General Electric Co.

(70) WIRE CHARTS. Four new data charts reduce as many as 50 pages of information to a single sheet. Information includes prices, stranding, temperature ratings, weights, diameters and wall thicknesses. Hatfield Wire & Cable.

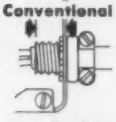
pres-SURE Romex Connector*

No other Romex Connector gives you all these important advantages . . .

LOWER INSTALLED COST — Save up to 2-minutes installation time per connector. On-the-job experience has shown that installed costs are lower than conventional connectors, — regardless of connector cost.

Save Valuable Space, Too!

MORE ROOM FOR WIRING — Connector extends less than 3/64" into box.



EASIER TO INSTALL — One quick simple squeeze with channel-lock or electrician's pliers simultaneously locks connector to cable and box. To install, merely insert cable in box knockout and slide connector over cable. No clamps, screws or lock nuts.

QUICKER TO REMOVE—An equally quick and simple squeeze at 90-degrees to installation "crimp" simultaneously unlocks connector from cable and box.

BETTER CABLE PROTECTION — Extra large bearing surfaces distribute pressure on cable to minimize insulation abrasion.

BETTER OVERALL PERFORMANCE —Exclusive "crimp-type" installation insures permanently-tight, vibration-proof connections of high tensile strength. No screws or nuts to work loose. Special high grade aluminum alloy can't rust.

Approved for 14/2, 14/3, 12/2, 12/3 and 10/2 non-metallic sheathed cable.
Also adaptable for use on:
- Portable cords or 10/3 Romex (½" or smaller dia.)
- (2) 12/2 or smaller Romex
- 12/2 and smaller UF
- 12/3 UF (by slightly pre-flattening connectors)

*Catalog No. 1050—An *exclusive* Buchanan development (Patent 2527227).

Ask your distributor, — or write for samples and Bulletin EC-5

BUCHANAN
ELECTRICAL PRODUCTS CORPORATION
HILLSIDE, NEW JERSEY

In Canada
GASACCUMULATOR COMPANY (CANADA) LTD.
12 GOWER ST., TORONTO 16, ONT.
Export
PHILIPS EXPORT CO.
100 E. 42nd ST., NEW YORK, N.Y.

IT TAKES A SPECIALIST LIKE STROMBERG-CARLSON

to provide the most flexible sound system

In keeping with the flexibility of the design of Bozeman (Montana) High School, *Yellowstone Electric Company*, Electrical Contractor, chose a sound communication system by Stromberg-Carlson.

This school was designed for easy, economical expansion to meet growing needs. The school's sound system will grow easily and economically with the school.

This flexibility is possible because Stromberg-Carlson systems are composed of *standard components* which can be arranged to meet any requirements of any client.

You can bid our equipment with complete confidence because:

- **Installation help and supervision are available from our factory-trained sound distributors in all major markets.**
- **Service and maintenance problems are negligible—as proved by thousands of installations now in use.**
- **Field sales engineers are at your service for consultation at any time.**
- **Our factory engineering staff is available to help solve complex installation problems.**

When you bid Stromberg-Carlson, you bid competitively—with assurance of a good profit—and an installation that will add to your prestige.

For further details, or the name of our local representative, write—no obligation.

"There is nothing finer than a Stromberg-Carlson"

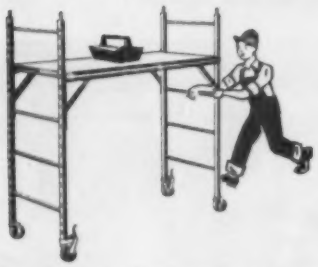
STROMBERG-CARLSON
A DIVISION OF GENERAL DYNAMICS CORPORATION
Special Products Division, Electronics Center
1453 N. GOODMAN STREET • ROCHESTER 3, N. Y.

ELECTRONIC AND COMMUNICATION PRODUCTS FOR HOME, INDUSTRY AND DEFENSE . . . INCLUDING HIGH FIDELITY CONSOLES; SCHOOL, SOUND, INTERCOM AND PUBLIC ADDRESS SYSTEMS

Your Job *Rolls Along*

with

BAKER SCAFFOLDS



Here's a scaffold that answers the need for rapid portability. It's made to the height, width and length for moving in close areas, through doors and over obstructions which normally lick "portable" scaffolds with underneath cross bracing. No need to knock down a Baker Scaffold to move it . . . yet, if unusual conditions require it, 1 man can easily take it down—and 1 man can put it back up in only 90 seconds.

The Baker Scaffold offers casters in optional wheel sizes of 3", 5" and 8" diameters to speed the portability. Also, there's a variety of accessories to further increase the convenience of the Baker Scaffold.

Complete information is available in our new catalog. Write today for your free copy. *Scaffold Literature* # 593

LISTED UNDER RE-EXAMINATION SERVICE UNDERWRITERS' LABORATORIES, INC.

BAKER SCAFFOLDS

DESIGNED FOR PORTABILITY • BUILT FOR DURABILITY

BAKER-ROOS, INC.
P. O. Box 892, Indianapolis 6, Indiana

Gentlemen: Send the folder described on Baker Scaffolds without obligation. ECM

Name_____

Organization_____

Address_____

City_____ State_____

DISTRIBUTORS IN PRINCIPAL CITIES

Reader's Quiz

QUESTIONS from readers on problems of industrial equipment, installation, maintenance and repairs. Answered by electrical maintenance engineers and industrial electrical contractors out of their experience. For every question and every answer published we pay $5.00

Control Circuits In Conduit

QUESTION S35—I would like to secure information regarding the installation of motor branch circuit wires and control wires in the same conduit. I am referring to a 440-volt, 3-phase, 60-cycle motor installation having the usual "start-stop" control circuit at the same potential. I have been informed that at distances greater than approximately 600 ft the contactor may fail to drop out when the stop button is depressed. What would be the reason for this failure? Would it be possible to circumvent this problem for greater distances by installing the control circuits of several motors in a separate conduit?—O.E.S.

ANSWER TO S35—With the stop pushbutton located roughly 500 ft from the controller, the contactor often fails to drop out when the stop button is depressed. This is caused by leakage current through the distributed capacitance between wires of the control circuit. When a distance is reached where the distributed capacitance allows a current to flow which exceeds the required holding current for the coil, then the stop button will have no effect.

Weather conditions may affect the value of distributed capacitance so that the installation may work properly on a sunny day and not at all on a rainy one.

Simplest and most reliable solution is to use dc control either using a dc coil, or a dc relay located near the starter operating in the ac control circuit. This eliminates leakage currents.

Occasionally this problem can be eliminated by using a lower voltage ac control circuit. For example, a 110-volt coil requires more holding current than a 440-volt coil; consequently, more leakage current is permissible before the contact fails to drop out.

To install control circuits in separate conduit will have no effect.—J.M.Y.

ANSWER TO S35—The problem cited by O.E.S. is one that is possible but uncommon, particularly in cases involving motor starters.

The problem resolves itself to a simple series resistance, reactance and capacitance circuit. The capacitor is formed by the control conductors. The contactor coil and control conductors form the resistive and inductive components. Therefore, the more remote the stop-start pushbutton, the greater the capacitance, inductance and resistance. Correspondingly, the less is the capacitance reactance.

Starter coils require approximately 80 to 85% rated voltage to pick up the contactor and only 50 to 65% rated voltage approximately to hold in the contactor (vertical lift contactors).

With the correct combination of inductance and capacitance, a voltage of sufficient magnitude will appear across the contactor coil and prevent it from dropping out when the stop button is depressed.

Figs. 1, 2 and 3 show the normal control circuit, the resolved series circuit and the voltage vector diagram, respectively. Hypothetical values for resistance, inductive and capacitive reactance are indicated in the series circuit simply to illustrate a condition that could occur.

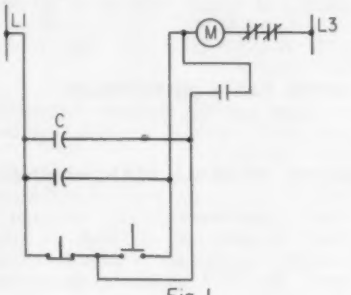


Fig. 1

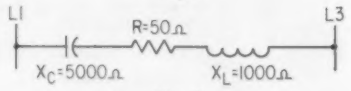


Fig. 2

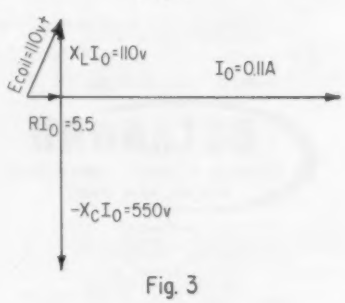
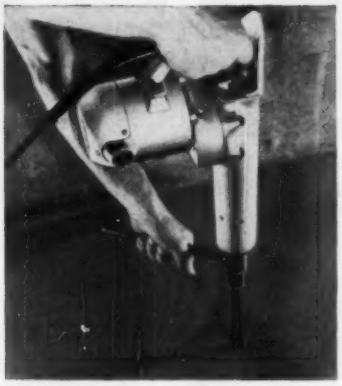


Fig. 3

Look what Black & Decker's 1⅛" Hammer can do for you!

BREAKING holes through concrete or brick; demolition work goes easier with bull point tool.



INSTALLING electric outlets in concrete is a cinch with a B&D Hammer.

TRIMMING excess metal or scaling after the job's done goes fast and easy with cold chisel.

MOUNTING electric signs, switchgear, etc. is fast work with powerful Hammer and star drill.

2,200 cutting blows a minute speed up electrical jobs

Here's the tool that helps you slash preparation time laying conduit in concrete floors and in scores of other jobs! Rugged Black & Decker Electric Hammers are *power*-packed to deliver thousands of hard, rapid, cutting blows to send your man-hours tumbling; output per worker climbing.

See for yourself what the B&D 1⅛" Hammer can do for you in drilling, digging, piercing, breaking, chiselling and dozens of other operations. Mail coupon for free demonstration or additional information. THE BLACK & DECKER MFG. CO., Dept. 1205, Towson 4, Md. (In Canada: P.O. Box 278, Brockville, Ontario.)

Look Under "TOOLS-ELECTRIC" in Yellow Pages

Leading Distributors Everywhere Sell

B&D Black & Decker®

Quality Electric Tools . . . Power-built for top performance

MAIL TODAY FOR FREE DEMONSTRATION

THE BLACK & DECKER MFG. CO., Dept. 1205, Towson 4, Md.

☐ Please arrange a free demonstration of your 1⅛" Hammer
☐ Please send additional literature

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

NOW, PLUG IN...OPERATE...MAINTAIN WITH

TOTAL SAFETY

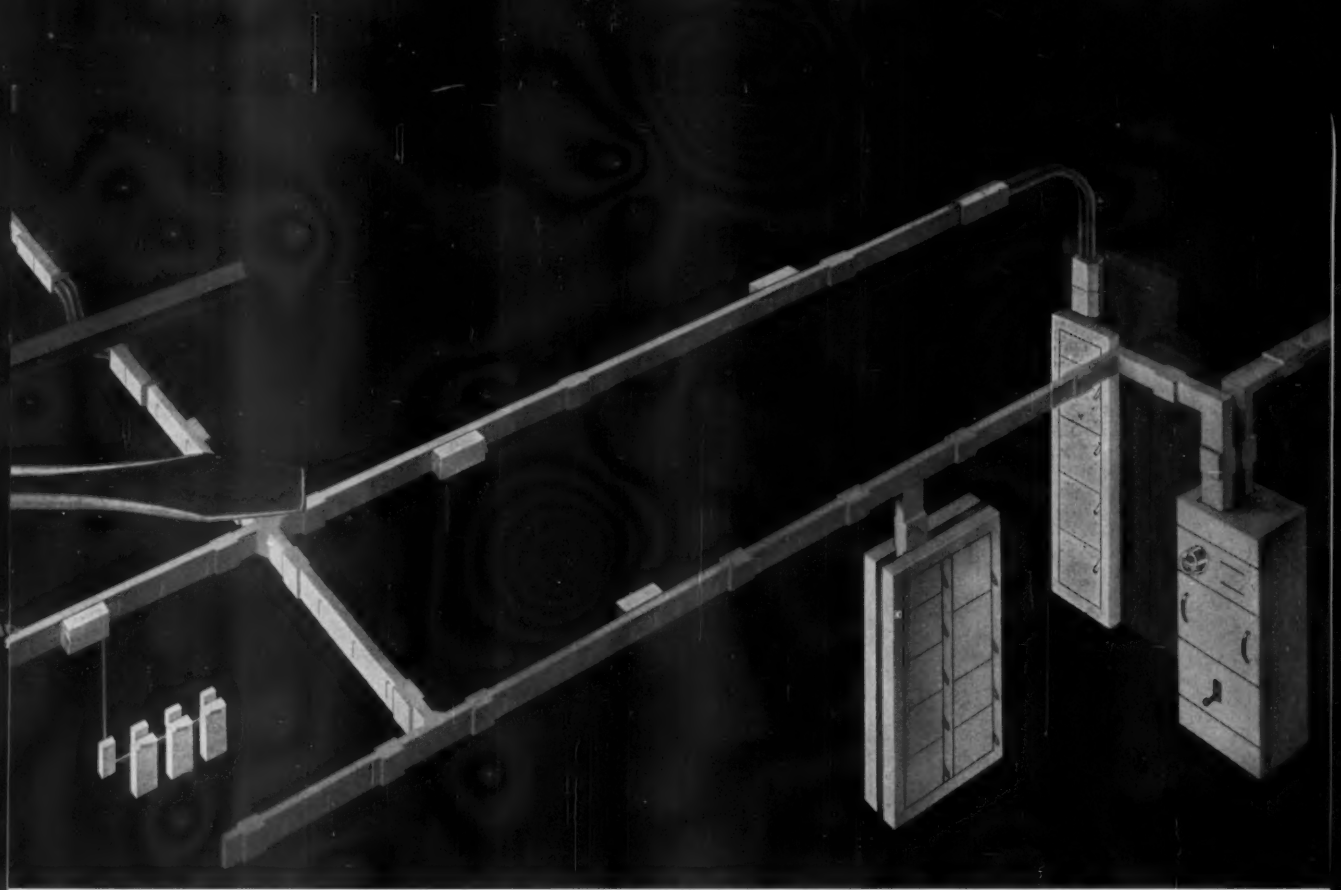
New EDP UNI-BUS Electrical Distribution System . . . now makes TOTAL SAFETY a fact! You cannot touch a "live" part in this new system—anywhere anytime, in any way! It positively eliminates any danger of accidental electrical contact during installation, operation, maintenance. Proof? "Uni-Bus" Busways, with TOTAL SAFETY, have been in wide use for over five years with *not one* report of accidental contact. Now, for the first time, TOTAL SAFETY is available in an entire electrical distribution system. The concepts are sound. The products are proven. And the entire "Uni-Bus" system is prefabricated—available from stock. This is the biggest single advancement in electrical systems in over 25 years. "Uni-Bus!"

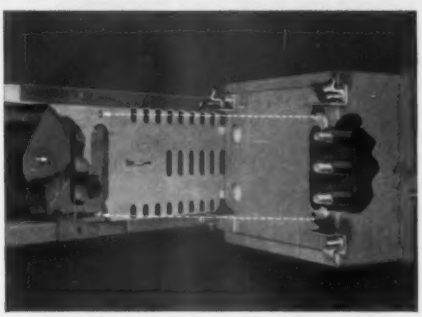
Let us introduce you to the *new* TOTAL SAFETY concept by quoting on your next job. It is the surest way of *proving to yourself* that EDP *safety* is not a claim—but a life-saving fact!

Write for the name of your nearest EDP Representative. Or, for further information, fill out the attached coupon for your free copy of the "Uni-Bus" Masterguard System Catalog. Electric Distribution Products, Inc., 2201 31st Street S.W., Allentown, Pa. A subsidiary of Electric Machinery Mfg. Co.

UNI-BUS by EDP

Electric Distribution Products, Inc.

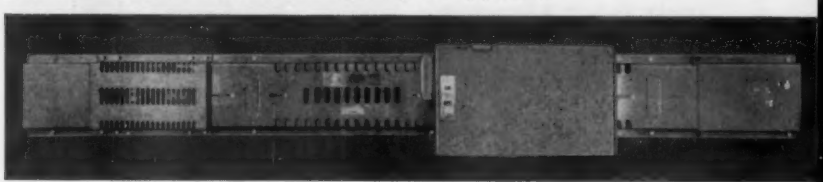


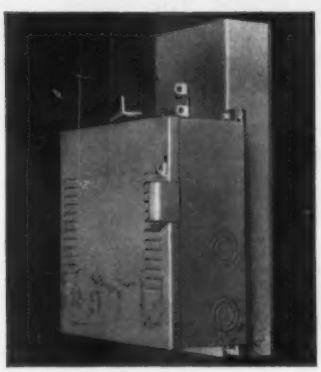


Reason for "Uni-Bus" TOTAL SAFETY is exclusive retractable plug-in contact mechanism that *locks* "live" bus bars behind safety slide, *locks* cover of device closed when there is line contact. When cover of control device is opened, plug-in contacts are automatically and instantly removed from bus bars . . . entire unit is "dead". There is absolutely no danger of accidents. "Live" parts are never exposed!

"Uni-Bus" Motor Control Center uses safety plug-in operation; provides flexibility (all control enclosures are interchangeable), lighter weight (150 to 200 pounds per section lighter than competitive units, saves 35% handling weight), smaller size (saves minimum of 33¼% of area, up to 50% aisle space), lower cost (all components are shelf-engineered into standard packages, available from stock). *It's the safest, most compact, lightest, most flexible motor control center available.*

"Uni-Bus" Electrical Distribution System is the only system with total safety throughout. Concept brings safety slide outlets used in "Uni-Bus" Busways down to working level in motor control centers, distribution panelboards, motor starters and enclosed switches—provides same plug-in convenience, flexibility, safety in every product.





"Uni-Bus" Busways are "shelf-engineered" for delivery from stock. No need for highly engineered products and systems. Dustproof design is available to resist the dangers of dust and oil laden atmospheres.

"Uni-Bus" Safety Switch is the *only* safety switch with total safety! Plug-in receptacles are placed at machine level to provide outlets as convenient as those in the home. Safety switch is plugged into outlet and power is immediately available. Switch can easily be moved without rewiring.

Electric Distribution Products, Inc.
2201 31st Street S.W., Allentown, Pa.

☐ Please send a free copy of the "Uni-Bus" Masterguard Catalog.

☐ Please have a representative call.

Name.....

Title.....

Company.....

Address.....

City.....

Zone..... State.....

You can count on ***Amp-trap**** . . . when you want to stop a 500,000 Ampere short circuit dead in its tracks. In fact, if ***Amp-trap*** is watching and waiting at your entrance switches or in your circuit breakers — you couldn't be safer. That's why those who know *insist on and get* ***Amp-trap***.

**Protected for your protection by 27 patents.*

Amp-trap is *"always awake at the switch"* . . . where current limitation with high interrupting rating is required . . . on general power circuits, on DC circuits, on standard and the new higher voltage networks, on busways and entrance switches, even on general electronic circuits.

Amp-trap is a true current limiter because it anticipates and stops dangerous short circuits long before they can become destructive. Nothing takes the place of ***Amp-trap***. There's one for every purpose. Ask for Bulletin 514-9.

®***Amp-trap*** is a registered trademark of The Chase-Shawmut Co. and refers to a current limiting fuse and herein is written ***Amp-trap***.

Amp-trap®

© 1959 The Chase-Shawmut Co.

Amp-trap® – "Awake At The Switch"

REGISTERED UNITED STATES PATENT OFFICE Est. 1895

THE **CHASE-SHAWMUT** CO.

374 MERRIMAC STREET • NEWBURYPORT, MASSACHUSETTS

Subsidiary of I-T-E CIRCUIT BREAKER CO., Philadelphia, Pennsylvania

Amp-trap® Tri-onic® Fus-ion® C-O-T® TRIONET® ONE O-T TIME

The values have no relation to an actual case.

On several occasions, I have been confronted with the same problem as O.E.S. Each time, with the aid of an inductance-capacitance bridge, I have taken measurements of a unit length (10 ft) of conduit containing the number and size of conductors that I had proposed to install. A few calculations, with the aid of the measured values, would show that no problem existed.

Tests using components corresponding to the measured values would prove nothing that calculations would not show. Reason—the actual installation consists of innumerable variables that are indeterminable and unmeasurable.

One of our installations, consisting of two Size 3 oil immersed starters with the control conductors installed in a common conduit and the start-stop pushbutton located 300 ft from the starters operates satisfactorily.

One solution to O.E.S.'s problem is to install a resistor in series with a contactor coil rated at a voltage less than the control circuit voltage. In doing so, the coil reactance is reduced and the voltage drop across the coil is reduced when the stop button is depressed.

O.E.S.'s suggestion of using separate conduits would help by increasing line reactance. It is questionable that the gain would justify the expense—H.C.D.

Pilot Lamps

QUESTION T35—In our plant we use 6-8 volt pilot lights on our 220-volt ac control circuits. The voltage to the lamps is reduced by any one of three ways: namely, a resistor or capacitor in series with the lamp, or 220/6-volt transformer.

Can someone suggest the reason for these variations? Which is best and why?—R.E.B.

COMMENT—The answers to the above question were published in the December 1958 issue of Electrical Construction & Maintenance, page 115, Z34. We usually catch duplicate questions sent in by our readers but this one got by us.—Editor

Dynamic Braking And Lowering

QUESTION U35—Please explain the difference between dynamic braking and dynamic lowering as used on dc series motors. In the

The PRICE is RIGHT!

National Price Service suggests the *right price* to service and hold customers. It is fair to the customer and to you. N-P-S will help you make a profit because it is a time-proved, business-like method of billing, estimating and costing your jobs, as well as checking your invoices and purchasing. Send for complete details.

HENDERSON-HAZEL CORP. Dept. A-95
13601 EUCLID AVENUE • CLEVELAND 12, OHIO

Gentlemen:
Please send me the complete story of National Price Service, how it will keep me up-to-date with changing material prices, and suggest profitable resale prices—quickly. No obligation.

Name_____

Title_____

Company_____

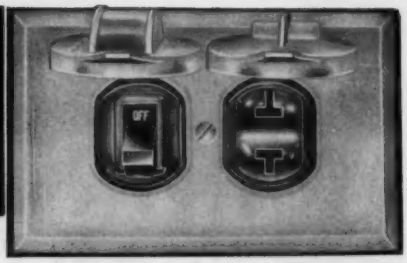
Address_____

City_____ Zone____ State_____

National Price Service
HENDERSON-HAZEL CORP.

13601 EUCLID AVENUE • CLEVELAND 12, OHIO

NEW! Exclusive! Different!



No. 241 COMBINATION SWITCH AND RECEPTACLE

BELL SAF-T-LOK (Pat. Pend.) Weatherproof OUTLET

FEATURING *Exclusive* STAY OPEN SNAP-COVER ACTION

STAYS OPEN IN SAFETY-LOCKED POSITION

SNAPS SHUT AUTOMATICALLY WITH SLIGHT PUSH

No. 219 SINGLE SNAP-COVER PARALLEL SLOT DUPLEX RECEPTACLE

No. 220 SINGLE SNAP-COVER 3-WIRE GROUNDING DUPLEX RECEPTACLE

Grounds metal parts of portable electrical tools, lawn mowers, etc. for safety in use with *Metallic* or *Non-Metallic* wiring systems.

SPECIFY BELL . .
The best in weatherproof devices

. . . the most COMPLETE line with EXCLUSIVE selling advantages

No. 210

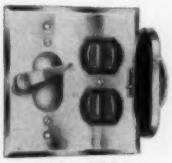
Exclusive SNAP-COVER locks open for easy, one-hand insertion of plug . . . yet snaps shut at a touch for weather-proof protection. Lid does not rest on wire or plug. Can't damage insulation if cord is jerked out. *Cover cannot be loosened or pulled off.*

No. 210—ONE-GANG SAF-T-LOK SINGLE RECEPTACLE

Bell—The *Complete* Line—The *Only* Line with SAF-T-LOK SNAP-COVERS OR SCREW COVERS in 1 or 2-gang Combinations.

No. 214 Flush Screw-Cover Duplex Receptacle

No. 216 Flush Switch (Single pole, T-rated)



No. 228 Combination Flush Switch & Snap-Cover Outlet

No. 233 Flush Switch and Duplex Screw Cover Duplex Receptacle

Make BELL your one source for the best in weather-proof and No-Shok devices, and Metal Wall Plates. *Write for Catalog and Prices today!*

BELL ELECTRIC CO.
5735 South Claremont Avenue • Chicago 36, Ill.

SEEMORE SAYS: LOOK! NEW!

Guth brascolite

GYM LIGHTS

You relamp 'em without ladders

From above, just snap-out the reflector. From below, use a relamping stick. No sky-high ladders to mess with!

They're available with hinged wire guard and 40° shielding louver —and with louver or guard only. Both pendant and recessed units are listed by Underwriters Laboratories, Inc.

High quality 60° beam ALZAK reflector for high efficiency, easy maintenance, long life.

THERE ARE MANY MORE GUTH GYM LIGHTS TAKE YOUR PICK:

Single, double, triple and quadruple units, for high or low bay installations, 100% downlight or with 15% uplight, round or square, pendant or recessed.

WRITE FOR GYM LIGHTING DATA SHEETS TODAY!

Guth THE EDWIN F. GUTH CO.
St. Louis 3, Mo.

TRUSTED NAME IN LIGHTING SINCE 1902

355

case of dynamic lowering is there an opposing voltage attempting to raise the load on the first controller point? These hoists are 25 hp and equipped with magnetic brakes. In other words, how is low controlled speed accomplished?—J.E.P.

ANSWER TO U35—The magnetic brake on your motor has a friction member which is pressed against the wheel by a spring and is released by a magnet. This brake is used only (1) to stop the motor after the speed has been reduced by the dynamic braking action; and (2) to hold a load stationary.

When the load is hoisted, an armature shunt resistor in connection with the series resistor is used for slow speed. When the load is lowered, the motor operates as a shunt motor. With an overhauling load, the motor operates as a generator. A resistor in the armature circuit absorbs this generated power. This is called dynamic braking. This braking action can be used for gradual speed reduction by the use of a series of step-by-step contactors in the resistor circuit.—W.R.S.

ANSWER TO U35—Dynamic braking is generally accomplished by disconnecting the armature from the line and connecting it to a resistance. In shunt or compound motors the shunt field remains connected as in motoring. In series motors the series field must be connected in series with an appropriate resistor to the line. The motor then acts as a generator so long as the load continues to turn the motor with sufficient speed to provide generation.

Dynamic lowering as applied to series hoist motors is similar, except that the armature also remains connected to the line. This is shown in Fig. 2. The motor starts to lower the load acting as a shunt motor. The resistor R1 allows enough current to flow to excite the series field and release the series brake. As the load becomes overhauling the motor becomes a generator, generating current Ia. This cur-

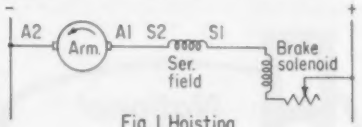


Fig. 1 Hoisting

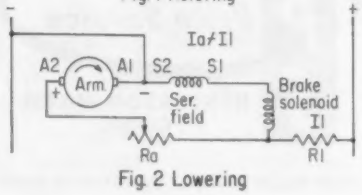


Fig. 2 Lowering

the
NEW LOOK
in **GENERATOR DESIGN**
on large Onan gasoline and diesel plants

Eliminates all moving parts in exciter and voltage regulator

Steps up performance in primary or standby installations

FASTER VOLTAGE RECOVERY—Rated voltage is restored within one second after load is applied or removed, compared to 5 seconds with rotating exciters.

LESS VOLTAGE FLUCTUATION—Voltage fluctuation with load changes is less than half that of standard-type generators.

GREATER RELIABILITY—Eliminates hundreds of electrical connections, the commutator and its brush rig.

FEWER ADJUSTMENTS—No extra sensitive adjustments necessary. Regulator has no delicate multiple contact points.

EASIER SERVICING—All exciter and regulator components are easily accessible. No dismantling necessary.

New Magneciter generators are now standard equipment on all Onan Electric Plants of 100, 125, 150, 175 and 200KW, as well as on many smaller sizes. A choice of Diesel or gasoline engine power is available on most Magneciter-equipped models. Complete specifications on any or all Onan units will be sent on request.

Onan ELECTRIC PLANTS

D.W. ONAN & SONS, INC.
2699 University Ave. S.E., Minneapolis 14, Minn.

NEW IDEAL SIMPLET PULLING ELBOWS and ADAPTERS

• MALLEABLE IRON • PERFECT 90° FIT

PNF PULLING ELBOW

Two female threaded hubs at precise 90° angle. Rigid, domed covers with full neoprene gaskets. Sizes ½" to 2".

PNH PULLING ADAPTER

Two hubs at perfect 90° angle, one female and one male threaded. Rigid, domed covers with full neoprene gaskets. Lock nut included. Sizes ½" to 2".

Make Wiring Around Corners a SNAP!

QUICK, EASY-TO-USE

Pull wires straight thru conduit and one side of elbow.

Make big loop of wires and pull thru other side of elbow and conduit. No obstructions inside elbow—gives smooth travel.

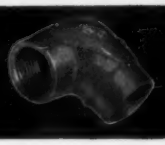
Pull wires taut from other end of system — cover attaches quickly with big screws, opens easily anytime.

MADE BETTER FOR YOUR NEEDS

- malleable iron, cadmium plated, chromate treated
- steel cover cadmium plated and chromate treated with larger screws designed to fit snugly in opposed corners without protruding inside
- cover domed for greater rigidity, provides more working space and more wire area inside
- full neoprene cover gasket (not cut out)
- milled surfaces assure tighter seal
- more metal at inside radius provides more strength, durability
- no obstructions inside, all smooth surfaces, tapped holes recessed
- precision tapered pipe threads positioned exactly 90° center to center in the same plane
- sold complete with covers, screws and gaskets — shipped assembled
- sizes marked on both covers and elbows

"L" TYPE PULLING ELBOW ALSO AVAILABLE

Malleable iron body has two female threaded hubs, at 90° angle. No-thread type also available. Swing style, steel cover attached to body. Angular opening permits straight pull of wires. Gaskets available at extra cost. Sizes ½" to 1".



SEE YOUR WHOLESALER, or send coupon.

IDEAL SIMPLET FITTINGS
A Division of Ideal Industries, Inc.
Pioneers in conduit fittings and electrical specialties.
1041-E Park Avenue • Sycamore, Illinois

Send Pulling Elbow data ☐

Clip and Attach to Your Letterhead

Your Name_____

Cat. #652001

New Porcelain Products
Pipe Mounting Wireholders

Porcelain Products *now* offers the finest universal pipe mounting wireholder available today. . . .

and here's why:

- Fits any 1¼" to 2½" pipe—ONE ITEM TO STOCK.
- Copper-bail reinforced insulator is stronger, with *extra* large wire holes—exceeds E.E.I. wireholder specifications.
- No loose parts—ready to install as is, on any size pipe.
- Bolts swedged rigidly to bracket for easy handling, installation.
- Slotted back bar permits installation without removing nuts.
- All steel parts are heavy gauge, hot-dip galvanized before assembly.
- Neat; trim, and compact for attractive installation.

Write for complete details

64 Years Porcelain Products, Inc. PP
CANEY, OHIO

rent Ia then adds to I1, adding to the excitation of the motor. The amount of braking is regulated by resistance Ra.

There is no reverse current tending to raise the load. Any current delivered from the line to the armature would actually tend to lower the load. It is possible that there could be regeneration into the line. However, normal conditions of load and circuit components would not allow current to flow into the line from the motor acting as a generator.—C.H.S.

Insects in Conduit

QUESTION V35—I have a problem of roaches in conduit constantly giving trouble eating and breaking down insulation on wiring in conduit. Is there anything we could do here?—H.W.L.

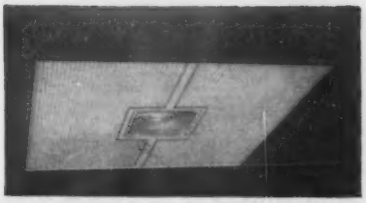
ANSWER TO V35—A similar condition in the south (with a different insect) was successfully eliminated with the help of an exterminator in the following manner.

A powder insecticide was mixed with "duct-seal" and one end of conduit was sealed. A gas insecticide was then introduced into the other end which was then sealed off the same as first end.

While the exact chemicals used cannot be given, the powder was of an arsenic content, while the gas was some type of cyanide. *PLEASE NOTE THE FOLLOWING AS THIS PROCEDURE IS DEADLY.* FIRST THESE CHEMICALS WERE TESTED IN A LABORATORY BY CHEMISTS FOR THEIR EFFECT ON INSULATION OF CONDUCTORS AND CONDUIT (RIGID). This whole operation was considered of enough importance and dangerous enough to be handled exclusively by a high rated exterminator. Later the gas was removed from the conduits and resealed, to prevent any reentrance of insects.

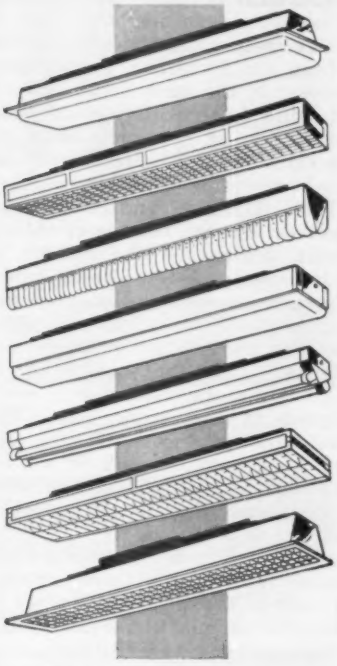
This whole operation required three weeks, during which there was no one else in the building except exterminators, and all electric power was disconnected, necessary power being supplied by portable unit.—C.L.

ANSWER TO V35—Before pulling in the wires, wind a good grade of friction tape on the wires by using 4-ft. tape to 1-ft of wire. Now dust the friction tape with sodium fluoride and pull in. The sodium fluoride should not be breathed. These insects go for our food, and a dark warm place. The conduit fill law for



WILEY

STARTER TYPE—RAPID START
SLIMLINE LIGHTING FIXTURES



- Pioneers in Fluorescence since its inception.
- Modern functional designs.
- Stock fixtures adaptable for all lighting layouts.
- Units designed for quick, easy erection.
- Patented E-Z Servicer.
- Designed and manufactured by WILEY with ETL Certified Electrical Components.

District Sales Engineers Available for Prompt Co-operation

For Full Information, write

R & W WILEY INC.
Dearborn at Bridge Street
Buffalo 7, N. Y.
Underwriters' Approved IBEW (A F of L)

SHERMAN TERMINAL LUGS AND CRIMPING TOOLS

SPEED INSTALLATION – REDUCE COSTS!

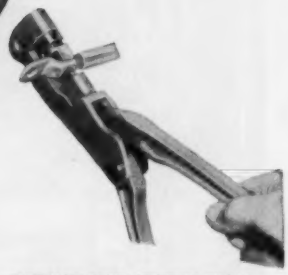
INDENTED CRIMP
FOR GREATER RESISTANCE
TO PULL-OUT

VOID FREE
CONNECTION

MONEY SAVER
SAVE UP TO 15%
WITH SHERMAN

SHERMAN
UNI-CRIMP
LUG

SHERMAN
"ST" LUG

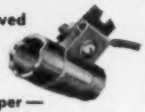


SHERMAN HAND CRIMPING TOOLS
Portable or bench mounted for fast, easy installation of money-saving Sherman terminal lugs.

ELECTRICAL FITTINGS

GF-13B
Solderless
Ground Fittings.

GF-23
Conduit
Solderless swivel-type Ground Fittings.



SL Approved Type Ground Clamps.
Pure Copper — Handles wire up to No. 8 AWG.

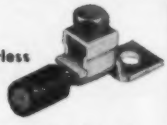
FOR WIRE and CABLE

GF-18, 19 & 20
Cast Clamps.
Cast Copper Alloy with non-ferrous screw.

"Bond-Rod"
GF-16 & 17
Ground Clamps.
Heavy Bronze one-piece construction.

SS
Solderless
Type
#14 thru #1000 MCM-AWG.

the line of Reliable quality!



SO
Solderless
Type
#14 thru 500 MCM-AWG.

You'll do better with
SHERMAN
-63 years best!

RETURN THE COUPON TODAY!

H. B. SHERMAN MFG. CO.
Battle Creek, Michigan

Show me how I can save up to 15% with your –
☐ LUGS ☐ CRIMPING TOOL ☐ BOTH

Name_____
Firm_____
Address_____
City_____ State_____

H. B. SHERMAN MANUFACTURING CO., BATTLE CREEK, MICHIGAN

NEW

FURNAS ELECTRIC MANUAL STARTER

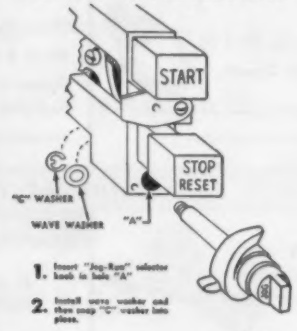
- 2-3-4 Poles
- Sizes 0 and 1; 7½ HP, AC—2 HP, DC
- Compact & Simplified
- Visible Contacts
- Pressure Terminals for Quick Wiring
- Positive Snap Action
- Trip-Free Thermal Overload Protection
- Modern Enclosures for Easy Installation

√ **SUPERIOR ELECTRO-MECHANICAL LIFE**—Only two moving parts—floating toggle and spring replace complex linkages. Unitized frame and arc box, silver-cadmium oxide contacts.

√ **DIRECT-ACTING THERMAL OVERLOADS**—Trip-free melting alloy type assures reliable motor protection, opens contacts independent of toggle. Second overload unit snaps into place on single phase starters.

√ **"JOG-RUN" SERVICE ACCESSORY**—The first manual starter with a "Jog-Run" accessory for fast, easy positioning.

"JOG-RUN" ACCESSORY



WRITE TODAY FOR BULLETIN 11-BL

1067 McKEE ST., BATAVIA, ILLINOIS

A58

FURNAS

FURNAS ELECTRIC COMPANY

BATAVIA, ILLINOIS

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

the modern thin insulations help the eggs to hatch and later on to work, which is my reason for the friction tape and the sodium fluoride.—H.S.

Speed of Fans

QUESTION W35—Which is more economical and efficient—a motorized small fan at high speed or a large fan at slow speed? Both deliver the same quantity of air at the same velocity. Is there a formula for determining the best size fan speed and number of blades?—E.B.

ANSWER TO W35—Much depends upon your definition of economy. A high-speed motor draws less current from the line than a slow-speed motor of the same horsepower. A fractional-hp circulating fan motor operating at 850 rpm draws approximately 25% more current than one operating 1725 rpm. Code Tables 21, 22, 23, and 24 have been revised upward because of the recent increase in the number of slow-speed motors. These tables have notes stating that very low speed motors may draw even more current than shown in the revised tables.

But why the trend toward lower speeds in these motors? It is certainly not done merely for the sake of using more current. It is done to increase overall efficiency in plants and offices by the reduction of the noise and of the annoyance experienced from the blasts of high-speed fans. Hence, there is an increase in overall plant economy in spite of the minute increase in current consumption.—W.R.S.

ANSWER TO W35—As a general statement, the large fan at slow speed is more efficient than a small fan at high speed. This is dependent, of course, on such factors as air volume, static (output) pressure and type of fan. For a propeller exhauster the noise level and vibration produced may be determining factors in fan selection, for both these items will increase markedly with an increase in speed.

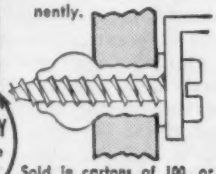
Since handbooks list some 14 items which affect the design of a fan, it is obviously difficult, if not impossible, to give a single concise rule for determining the best fan speed and number of blades (see Mark's Mechanical Engineer's Handbook). Except on direct-motored units fan speed is usually the last item of concern.

Probably the best guide is to refer to a standard manufacturer's

NEW Hi Wally PLASTIC SCREW ANCHOR
FOR HOLLOW WALL CONSTRUCTION

NEW DESIGN
NEW FEATURES

The only plastic screw anchor with "toggle-bolt" action. Just drill hole . . . insert Wally . . . turn in screw. Lower end backs up and bulges *behind* wall material. Holds permanently.



Sold in cartons of 100, or handy plastic kit incl. screws and drill. No. K-10, $4.75.

SEND FOR FREE SAMPLES

Hi NEW CONDUIT "DRIVE-STRAPS"

Hi PLASTIC ANCHORS
FOR CONCRETE, BRICK, CINDER BLOCK

Hi MACHINE SCREW LEAD ANCHOR KITS

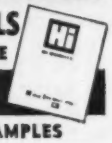
Hi BAKELITE SCREW-ON WIRE CONNECTORS
AND THE NEW LOK-IT WRENCH

Hi TAPE-MATE WINDER
AND FISH TAPE REELS

Hi RIGID & TW CONDUIT "SNAP-STRAPS"

Hi MUSHROOM HEAD TOGGLE BOLTS

Hi CARBIDE DRILLS
2 TYPES AVAILABLE



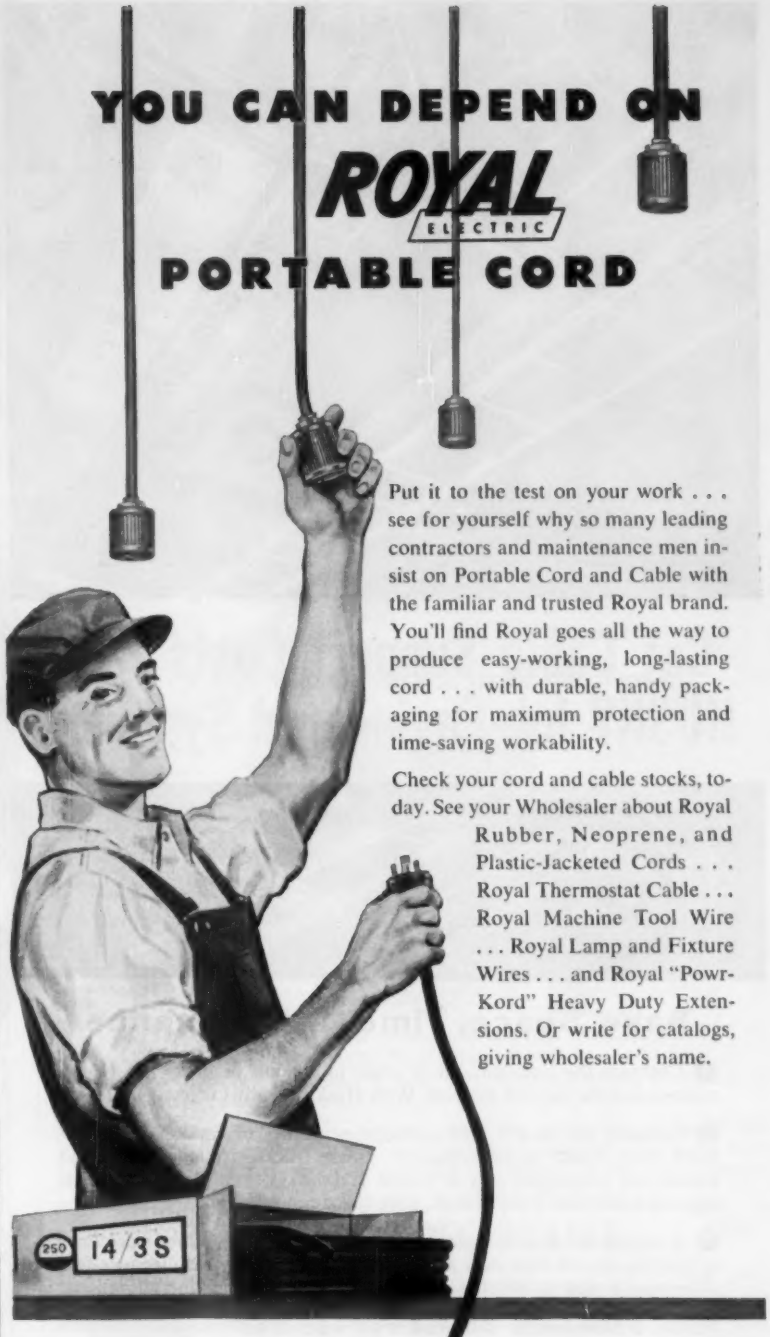
MAIL COUPON FOR 1959 "HI" CATALOG

☐ SEND "WALLY" SAMPLES

NAME_____
FIRM_____
STREET_____
CITY_____ STATE_____

Hi HOLUB INDUSTRIES, Inc.
442 ELM ST. • SYCAMORE, ILL.

YOU CAN DEPEND ON ROYAL ELECTRIC PORTABLE CORD

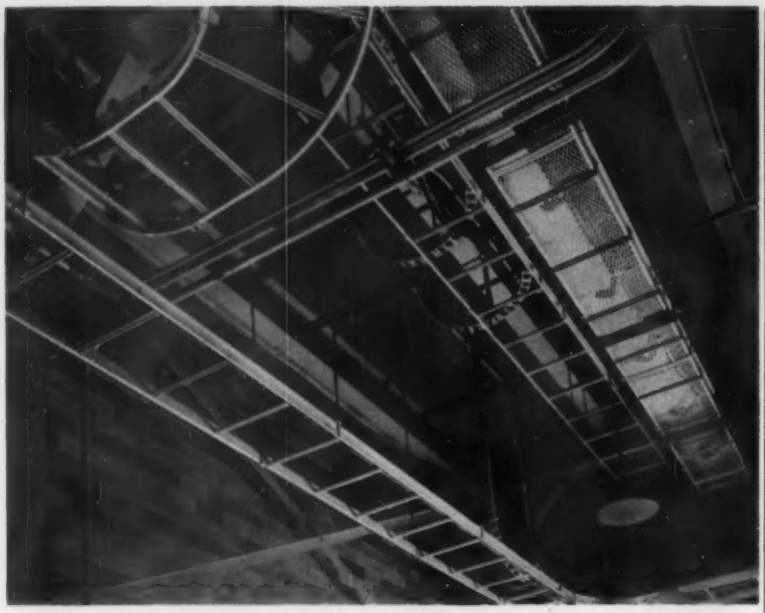


Put it to the test on your work . . . see for yourself why so many leading contractors and maintenance men insist on Portable Cord and Cable with the familiar and trusted Royal brand. You'll find Royal goes all the way to produce easy-working, long-lasting cord . . . with durable, handy packaging for maximum protection and time-saving workability.

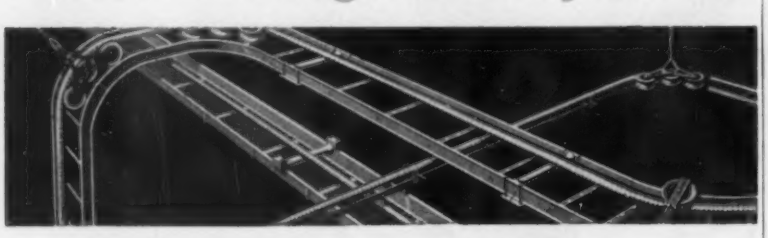
Check your cord and cable stocks, today. See your Wholesaler about Royal Rubber, Neoprene, and Plastic-Jacketed Cords . . . Royal Thermostat Cable . . . Royal Machine Tool Wire . . . Royal Lamp and Fixture Wires . . . and Royal "Powr-Kord" Heavy Duty Extensions. Or write for catalogs, giving wholesaler's name.

ROYAL ELECTRIC
...an associate of ITT

ROYAL ELECTRIC CORPORATION • PAWTUCKET R. I.



Cut Cable Support Costs with HUSKY Job-Engineered Systems!



Save Space, Time, Maintenance

❶ Compare the installed cost of cable in conduit or duct with Husky cable-in-free-air support systems. With Husky this cost is less.

❷ Compare the weight and cumbersome nature of conduit and duct-work with Husky cable-in-free-air. Husky racks, troughs, trays and baskets are lightweight, easy to handle, and the system is flexible, eliminating pull boxes and many splices. Save space . . . save time.

❸ Compare the maintenance costs and difficulties of adding more lines or making repairs with duct and conduit versus Husky maintenance-free aluminum supports, which are always accessible for making alterations.

Finally, compare other cable-in-free-air support systems, with the *electrically* as well as *structurally* sound Husky Cable Support System. When you've made the comparisons you'll understand why Husky is preferred by so many owners, engineers and contractors.

Want proof? Write for free complete line Catalog or send us your cable support problem for analysis.

Representation from coast to coast

HUSKY PRODUCTS, INC.

5304 Vine Street Cincinnati 17, Ohio

catalog and find a unit providing the desired characteristics. While all the data needed to design a fan is not given (number of blades, pitch, angle etc.), you can get an idea of how your specific problem has been solved by others. Fan manufacturers have relied for years on trial and error solutions for original design, followed by the use of dimensional analysis.—H.S.E.

Can You Answer These QUESTIONS

QUESTION G36—Our rural distribution system has approximately 500 water heaters of various sizes in a certain substation area. We plan to install control equipment in this corporation-owned housing.

Our wholesale power rate is capable of a reduction of a kilowatt in the monthly billing demand to reduce the bill approximately $1.50. It is estimated that our maintenance and operation costs for the equipment will average $2.79 per unit per year. We have price quotations from leading jobbers for the control systems, minus accessories. These include potential transformers, transformers, lightning arresters, meter sockets, fused cut-outs, wire, conduit, buildings and the cost of the installation totalled to the prices at hand.

Has any reader sufficient experience to tell us how much can be profitably invested in the water heater control equipment for our premises?—P.C.Z.

QUESTION H36—Recently we installed an electric heating element connected 3-phase delta. The power supply is from two transformers connected open delta. The current in two phases is 28 amps and in one phase, 12 amps. Are all open delta connections this far out of balance? If so, Why?—H.G.R.

QUESTION J36—There are differences of opinion on installing bearings on motors. Some say heating in oil is proper, while others believe in using a press. We have used a cone heater to expand the inner race until it will slip on the shaft. Then it is left to cool. This procedure has been used for years. Does anyone have any other ideas?—E.S.H.

PLEASE SEND IN YOUR ANSWERS BY JUNE 15

KLEIN

THE THRILL THAT
ONLY GOOD TOOLS
CAN GIVE

"Since 1857"

It's a pleasure to use good tools —pliers that grip tight . . . that cut through tough wire easily . . . that reach confined spaces.

Linemen and electricians know that they can rely on their Kleins—side cutters, long nose, oblique cutters—famous for quality for a century.

There is a Klein Plier exactly suited to every electrical need—carried in stock by better electrical suppliers everywhere.

FREE POCKET
'TOOL GUIDE

A free copy of the new Klein Pocket Tool Guide will be sent on request without obligation.

Mathias KLEIN & Sons
7200 McCORMICK ROAD • CHICAGO 45 ILLINOIS

EAGLE HAS NO DOUBLE STANDARD

★ *No Secondary Line*
★ *Only One Quality . . .*

THE BEST

- UL APPROVED
- SPECIFICATION GRADE
- POPULARLY PRICED

Cat. No. **827**

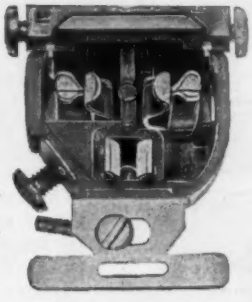
PARALLEL "U" GROUND DUPLEX RECEPTACLE
15A-125V
Available in Brown or Ivory

• *EASY WIRING HOLES FOR SPEEDY SNUB WIRING*

Double Wipe Phosphor Bronze T Contacts . . . Virtually Indestructible

Ground Thru Hex Green Grounding Screw — Or Thru Strap

⅞" Long Mounting Screws Attached To Strap



Easy—Positive Connections.

Large Head Binding Screws Take To #10 Wire

Polarized Parallel Slots Accommodate Both Regular and Polarized 2 Wire Caps

Heavy Yoke Extends Over Entire Back—Sits Better in Box — Will Not Loosen

PLUS— *CONVENIENT "BREAKOFF" FEATURE TO PROVIDE TWO CONVENIENT CIRCUITS, IF DESIRED.*

For Use on 125 Volt Grounding System. With Equipment Made in Accordance With the New National Electrical Code.

Never before a Parallel "U" Ground Receptacle acclaimed as this EAGLE No. 827. It has everything you want including competitive price, excellent features for quick and easy wiring, perfect engineering to eliminate callbacks.

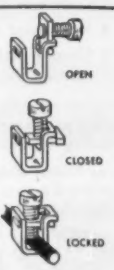
SPECIFY EAGLE—do not accept substitutes

SURFACE RANGE RECEPTACLE

with FABULOUS, QUICK WIRING

"QUIK-LOK" PATENTED TERMINALS

No fooling—no fussing with these excellent "QUIK-LOK" terminals. Just flip open top lug, put in cable, flip down lug, tighten screw to lock. "Protects" terminals, assures solid, positive contact. Speeds wiring. Saves time, trouble—and money.



No. 112B—BROWN
No. 112V—IVORY

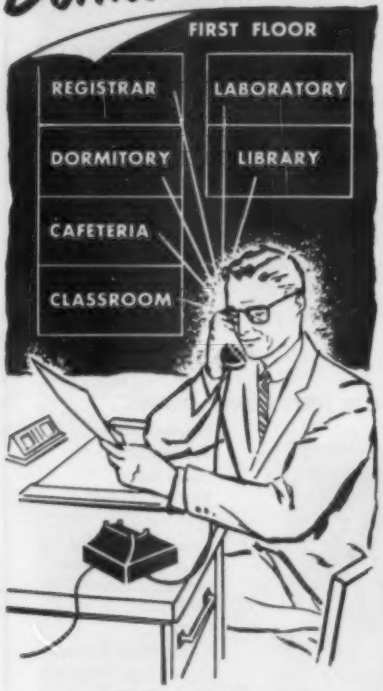
3 wire polarized
50A-125V
Underwriters' Listed

EAGLE ELECTRIC MFG. CO., INC.

LONG ISLAND CITY 1, NEW YORK

"PERFECTION IS NOT AN ACCIDENT"

Auth SINCE 1892 INTERCOM TELEPHONE SYSTEMS
for Schools and Dormitories



The most efficient and least expensive method of voice communication between a central point and a number of outlying points. Various systems available . . . no limit to capacity. Some advantages of AUTH Intercom Telephone Systems are:

- Privacy of conversations
- Low initial investment
- No rental charges
- Simple installation, operation, and maintenance

For dormitories, each room telephone available with visual indication of call received during absence at only small extra cost.

For further details on AUTH Intercom Telephone Systems, clip the coupon below and mail now.

Auth
AUTH ELECTRIC CO., INC.
Dept. EC-5 34-20 45th St.
Long Island City 1, N. Y.

☐ Please send catalog data on AUTH Intercom Telephone Systems
☐ Please have your representative call

Name_____
Company_____ Title_____
Address_____
City_____ Zone____ State_____

Questions on The Code

Answered by:

B. A. McDONALD, *New York Board of Fire Underwriters, Rochester, N. Y.*
B. Z. SEGALL, *Consulting Electrical Engineer, New Orleans, La.*

Continuity Over Flexible Conduit Connectors

Q. *Does flexible metallic conduit terminated with metallic connectors provide a continuous ground?*

Does liquid-tight flexible metallic conduit terminated with liquid-tight connectors having metallic ferrules provide a continuous ground?—L.C.D.

A. According to the provisions of Section 2574 of the code, "The electrical continuity of metallic raceway systems and cable armor that are to serve as grounding conductors shall be assured. At points where raceway or armor connects to metal enclosures, any non-conducting coating which might interrupt such continuity shall be removed unless fittings are used which are so designed that such removal is unnecessary."

This code provision concerns that part of the wiring system beyond the service equipment when the voltage does not exceed 250 volts to ground. When service equipment is involved, the provisions of Section 2571 and 2572 apply. When voltages exceed 250 volts to ground the provisions of Section 2575 apply.

The status of flexible conduit with respect to its use as part of a raceway containing service entrance conductors is covered by Section 2383-c. This rule requires that the flexible conduit be bonded by a copper conductor not smaller than No. 8. The occasion for the rule concerns the situation which results when a service-entrance conductor becomes grounded. With the neutral conductor grounded and connected to the service equipment, the fault current follows a short circuit over the flexible conduit. Since the short circuit current is primarily limited by primary fuses on the distribution system, a heavy current will flow over the flexible conduit and its connectors. Such a high impedance path in the grounding circuit usually results in arcing at the connectors and excessive heating of the flexible conduit. In fact the flexible conduit could be destroyed before the fault is cleared. In order to avoid such a hazard the code requires the flexible conduit to be bonded.

When flexible conduit is used as a wiring method beyond the service equipment, and the voltage of the conductors it contains does not exceed 250 volts to ground, the continuity of the flexible conduit with conventional connectors is considered sufficient to satisfy the provisions of Section 2574. The situation is quite similar to that which prevails when armored cable is used.

When flexible conduit is used for enclosing conductors which operate in excess of 250 volts to ground, the provisions of Section 2575 apply, or the bonding provision of Section 2572-d could be used. Section 2575-a recognizes threadless fittings, made up tight, with conduit or armored cable. Threadless fittings are necessarily used with flexible conduit but the connection to the box enclosure should be fortified by the use of two locknuts as covered by Section 2575-b, or by threaded hubs integral with the box. In the case of flexible conduit connections to motors, where vibration is a factor of importance, it appears that the short section of flexible conduit ordinarily used should be bonded. While the code does not require such procedure to be followed, this method has been used by many who know from experience that the use of flexible conduit at motor terminals is vulnerable to mechanical abuse and vibration, and believe that the minimum code rules do not adequately cover this particular application. Liquid-tight metal conduit is also an answer to this problem.

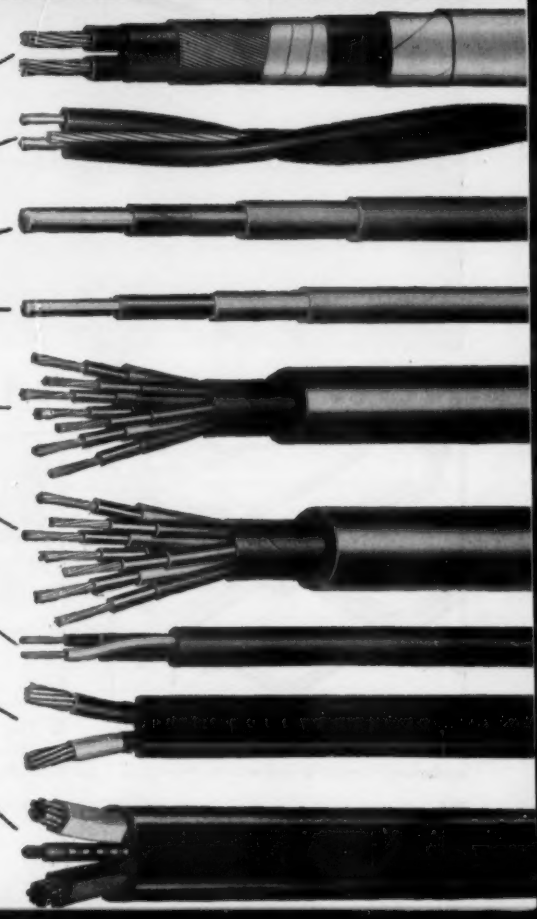
Insofar as liquid-tight flexible metal conduit is concerned, it appears to me that the threadless fittings designed for use with this type of flexible conduit and approved by UL fully satisfy the provisions of Section 2574 and 2575. Such fittings serve the dual role of providing a liquid-tight connection and a mechanical connection to the

DISTRIBUTION • BRANCH CIRCUITS • FEEDERS

WHEN OPERATIONS REQUIRE	SELECT
75°C Wet or Dry Building Wire	Collyer RHW
75°C Wet or Dry RR Power Cable	Collyer Style RR (RHW Insulation)
85°C Wet or Dry-RR Ozone Resisting Power Cable	Collyer Style RR (Butyl Insulation)
75°C Power Cable, Dry Locations	Collyer VCB with or without interlocking armor
75°C Power Cable, Wet or Dry Locations	Collyer VCL with or without protective neoprene sheath
85°C Overhead Ozone Resisting Power Cable	Collyer Self-Supporting Aerial Cable (Butyl Insulation)
110°C Power Cable, Dry Locations	Collyer Type AVA
110°C Power Cable	Collyer Type AVL
150°C Power Cable	Collyer Silicone Power Cable

WHEN THE CALL IS FOR CABLE . . . CALL FOR Collyer

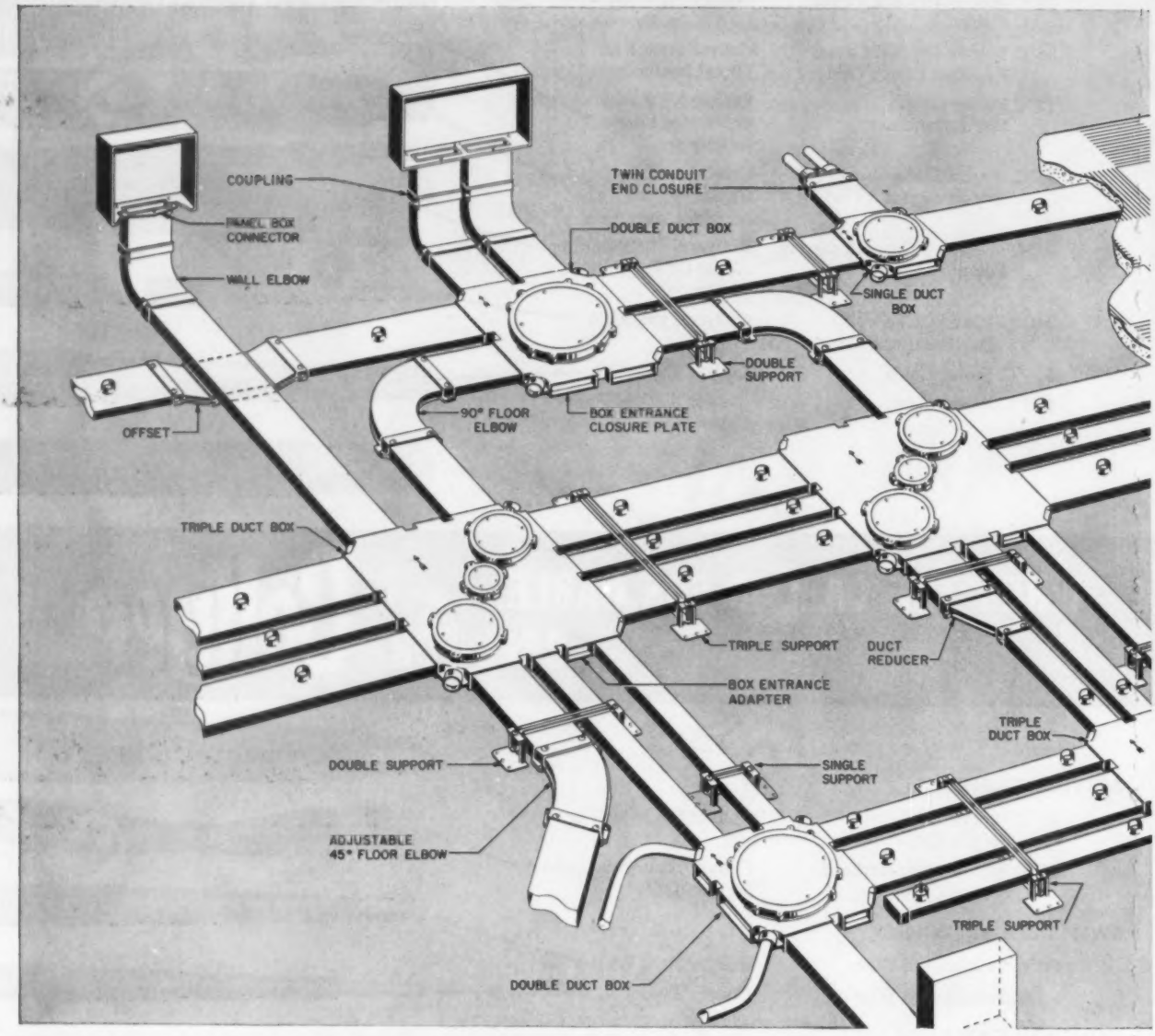
SERVICE CABLE	
75°C Wet or Dry Service Cable	Collyer SE Style U or A
75°C Wet or Dry Overhead Service Cable	Collyer Neutral Supported Service Cable
SWITCHBOARD WIRE	
90°C Switchboard Wire	Collyer Type AVB
90°C Switchboard Wire	Collyer Type TA
CONTROL CABLE	
75°C Wet or Dry Small Diameter Control Cable	Collyer C-141 (Polyethylene, Nylon, PVC)
75°C Wet or Dry RR Ozone Resisting Control Cable	Collyer RR Control Cable (Oil Base Insulation)
PORTABLE CABLES	
Portable Power Cords	Collyer SJ or SJO, Light Duty Collyer S or SO, Heavy Duty
Heavy Duty, Without Ground	Collyer Type W
Heavy Duty, With Ground	Collyer Type G



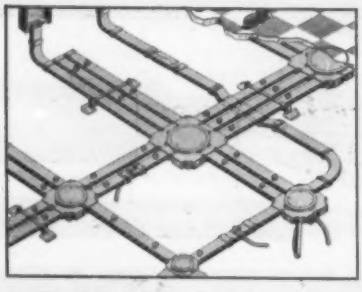
for complete details, write

Collyer Insulated Wire Company
265 Roosevelt Avenue
Pawtucket, Rhode Island

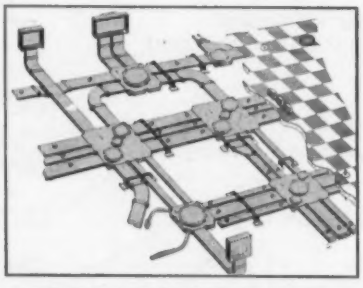
General Electric



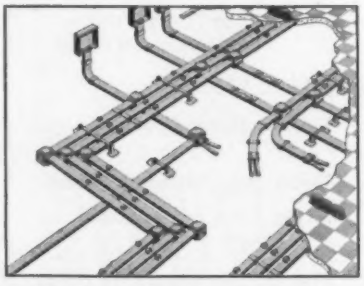
NOW General Electric's 4 great systems meet every design, cost, and



1. The G-E single-level standard duct system for installations where a standard underfloor layout is desired.



2. The G-E single-level BIG DUCT system for standard layouts where greater feeding capacity is required.



3. The G-E two-level duct system for layouts requiring great flexibility of feeding arrangements.

announces new...

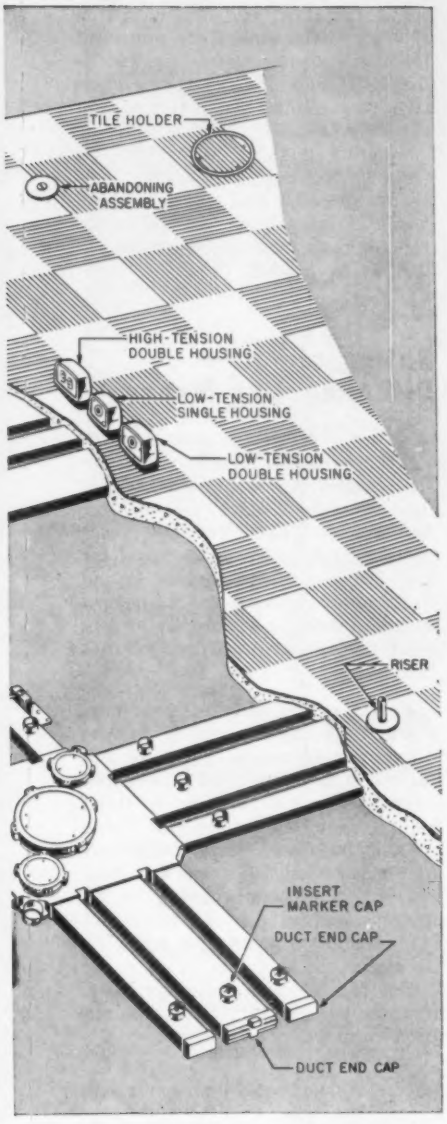
BIG DUCT

UNDERFLOOR WIRING SYSTEM

Large-capacity duct meets growing electrical needs

Here's your answer for standard layouts that need greater feeding capacity than you can get with a standard-size, single-level duct system. It's General Electric's new single-level steel BIG DUCT system, utilizing duct with an 8½-inch cross-sectional area. The system includes boxes, components, and accessories necessary to utilize BIG DUCT either by itself or in combination with the G-E single-level standard duct.

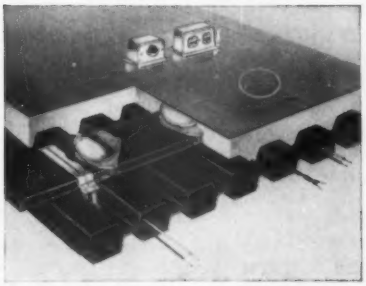
Junction boxes have been provided to accommodate runs of BIG DUCT as well as several combinations of BIG DUCT and standard duct. All height and leveling adjustments are made outside the box, making it unnecessary to remove the cover. Duct entrances have been spaced so that, by using plugs and/or reducers, the new system may, if necessary, be used in connection with the duct and boxes of the G-E single-level standard duct system. The new General Electric single-level steel BIG DUCT system can be installed in any type of floor construction that has a minimum fill thickness of three inches.



Progress Is Our Most Important Product

GENERAL ELECTRIC

installation requirement



4. The G-E cellular-steel floor wiring system which permits outlets in every 6 inches of floor area.

FOR COMPLETE INFORMATION on any G-E system—or to get the answer to any question you may have, send this coupon:

General Electric Company
Conduit Products Department, Section CU-87-518
Bridgeport 2, Connecticut

Please send me full information on:

☐ **G.E.'s new BIG DUCT wiring system and single- and two-level steel underfloor wiring systems.**

☐ **G.E.'s outstanding cellular-steel floor wiring system.**

Name_____

Title_____

Company_____

Address_____

Pull Cable Fast

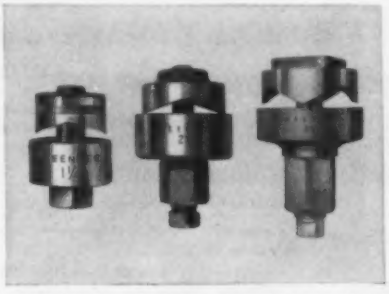
through open or concealed conduit with Greenlee Electricians' Cable Puller . . .

Cable can be pulled at any angle, from any convenient location with a GREENLEE No. 765 Cable Puller as shown here. Puller may be hand-operated, as shown at left, or power-operated, with any portable electric drive as shown above. Drum swivels to give complete operating clearance.

Here's the way to simplify large-size cable pulling. With a GREENLEE No. 765 Electricians' Cable Puller on the job you get it done far faster . . . easier . . . and at far less cost. This powerful puller exerts a maximum pull of 7,500 pounds and has two operating speeds . . . one for fast work, the other for a steadier, heavy pull. At all times the pull is in line with the conduit . . . no strain on the hangers. Portable, easy to set up and operate. Use it for exposed or concealed conduit . . . high up, in close quarters, or out in the open. See your electrical distributor for details on this timesaving GREENLEE equipment or write for descriptive literature.

Cut conduit holes quickly, easily with Greenlee Knockout Punches

Complete range of knockout punches to make openings for all standard conduit sizes ½" - 5". Fast, easy cutting through 10-gauge metal. Every cut is quick and clean — slug falls free in die. Hand, ratchet, or hydraulic driver operated. Wide choice of sets.



OTHER GREENLEE TIMESAVING TOOLS FOR ELECTRICAL WORK . . . CONDUIT BENDERS, KNOCKOUT PUNCHES, KNOCKOUT PUNCH DRIVERS, PIPE PUSHERS, BORING TOOLS

GREENLEE TOOL CO. GREENLEE

1759 Columbia Ave., Rockford, Illinois

box or enclosure. To satisfy the first condition, the second is likewise satisfied. It is significant to note that the provisions of Section 3511 definitely require that the terminal fittings used with this type of flexible conduit be approved for the purpose. Such terminal fittings, listed by UL, assures an effective grounding connection when properly installed. The ferrule, or grounding bushing, to which you refer is a component of the connector assembly and serves the purpose of providing an adequate ground path over the connector.—B.A.McD.—5/59/1

Rating of Disconnecting Means

Q. *We have a 3-phase sealed (hermetic type) refrigeration compressor motor marked full load current* 32 *amps, locked rotor* 140 *amps. What size horsepower rated switch would be required for the disconnecting means? Would Section* 4403*b and Table* 25 *govern the size horsepower rated switch used for interrupting capacity?—C.T.*

A. Based on the full load current the hp rating of the disconnecting means would be obtained from Table 24 of Chapter 10 (new Section 430-150). In the third column from the left in this Table it will be found that a 220-volt motor rated at 27 amps full load current corresponds to a 10 hp motor. The value of 40 amps full load current corresponds to a 15 hp motor.

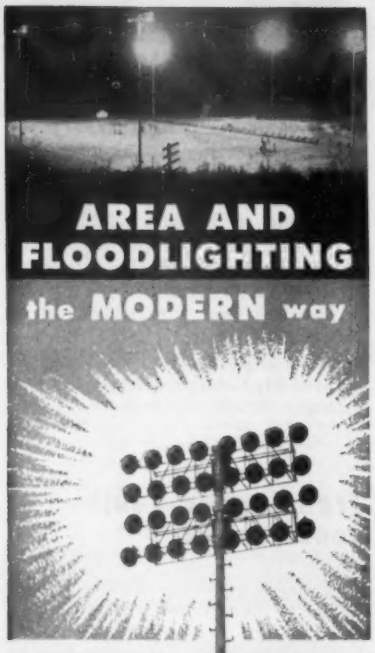
For the 32 amps value we have, it would be necessary to interpolate for the hp value, as follows:

$$\left[\frac{32-27}{40-27}\times(15-10)\right]+10,$$

$$\left[\frac{5}{13}\times 5\right]+10=1.9+10=11.9\text{ hp.}$$

Since, as a practical application, it will be found that the disconnecting means will be rated either as a 10-hp or a 15-hp switch, this actual value will, therefore, have no practical significance. We would, therefore, have to use a disconnect rated at 15 hp on the basis of the full load current rating of this motor.

On the basis of locked rotor, Table 25 of Chapter 10 (new Section 430-151) would be applied. Here we note that the 140-ampere locked rotor value is between a 7½

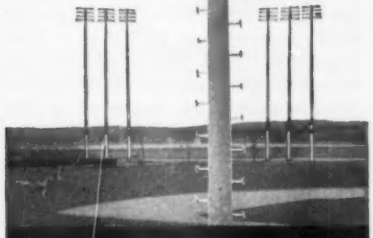


TULITO

TAPERED STEEL LIGHTING TUBES

For
- Baseball Diamonds
- Football Fields
- Playgrounds
- Shopping Centers
- Truck Terminals
- Railroad Yards
- Race Tracks
- Radio and TV Towers
- Transmission Power Lines

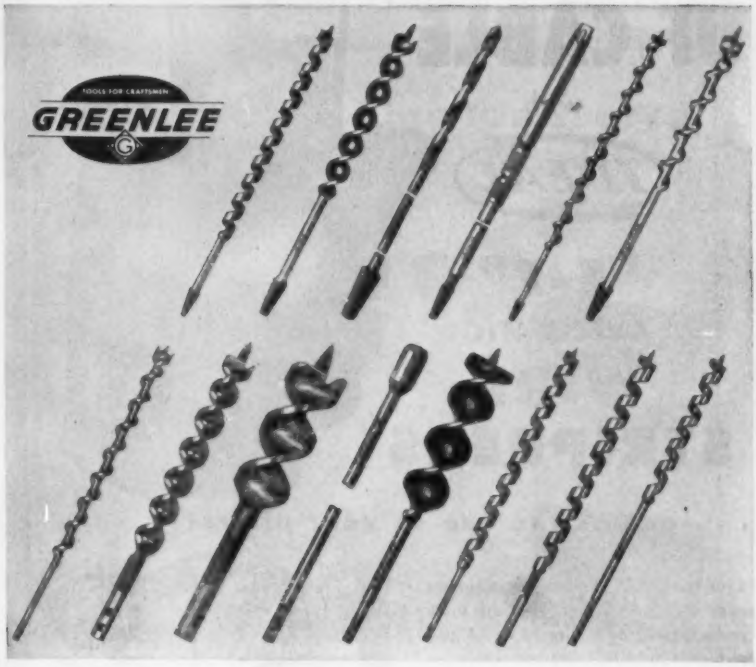
Engineered for Permanence, Strength and Safety...
Designed to accommodate from 2 to 40 lights.
Streamlined to enhance the appearance of any lighted area.



MEYER MACHINE, INC.
RED WING, MINNESOTA

Fast-Cutting

Precision-Made Greenlee Tools for Electrical Installation Work



high-quality bits and extensions for every power drill or brace job

Installations go smoother, faster when you standardize on precision-made GREENLEE tools. Power drill and hand brace types . . . various styles and lengths for all types of electrical work. All of highest quality materials, carefully heat-treated and made with correct design for fast, accurate boring and long life under hard usage.

The GREENLEE line includes Electricians' Auger Bits and Power Bits, Solid-Center Auger Bits, Bell Hangers' Drills, Expansive Bits, Pipe Bits, Ship Augers, and Extensions.

GREENLEE Power Bits for ½" and larger chucks feature new hexagon shank for positive drive. Eliminates slippage on tough power boring jobs. See your distributor for these timesaving tools or write for descriptive bulletins.

new *ZIP BIT* wood boring power bit and extension

Greenlee No. 33 spade-type electric drill bit with exclusive nonslip *hexshank*. Bores in any wood, at any angle, any speed.

- Hex shank gives positive, *nonslip* drive . . . added strength.
- Chucks quickly, accurately in any ¼" or larger electric drill.
- Cutting edges easily resharpened.
- 13 sizes ¼"-1"

No. 901 Bit Extension for Greenlee ZIP BIT. Hex shank fits ¼" electric drills. 12" length. Holds all bits with ¼" shank.

OTHER GREENLEE TIMESAVING TOOLS FOR ELECTRICAL WORK: CONDUIT BENDERS, PIPE PUSHERS, KNOCKOUT PUNCHES AND DRIVERS, CABLE PULLERS

GREENLEE TOOL CO. GREENLEE

1760 Columbia Ave., Rockford, Illinois

NOW! STRIP UF CABLE with IDEAL "E-Z" AUTOMATIC WIRE STRIPPERS

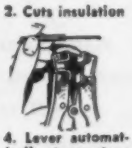
. . . as easy to use as your pliers!

With the "E-Z" it's easy to strip the outer sheath and web, then the inner conductors (2 or 3 wire 12 or 14 ga.) from non-metallic sheathed cable — without cutting, nicking or other damage to the wire ends. The "E-Z" Automatic is lightweight yet durable all-steel construction for long, heavy duty service life. Available in 5 other models for stripping various types of wire from 8 through 26 ga.

1. Clamps wire

2. Cuts insulation

3. Strips it off



4. Lever automatically stops return of arms until wire is removed.

. . . and for ordinary non-metallic cable

IDEAL DELUXE CABLE RIPPERS

A practically designed mechanic's tool for quickly and easily ripping the outer sheath from non-metallic covered cable up to ½" O.D. Faster—just insert the cable, set blade depth and rip away. Rigid frame and cradle assure straight cut. Replaceable steel blade; durable aluminum rip-grip for speed and safety.

Sold through America's Leading Distributors—In Canada: Irving Smith, Ltd., Montreal

IDEAL INDUSTRIES, Inc.
1041-E Park Ave., Sycamore, Illinois

Please send us your catalog on the complete line of Ideal Electricians Tools.

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

IDEAL

hp (132 amps in the fifth column from the left) and a 10 hp (162 amps). We could find the actual hp by interpolating as above, but here again this actual value would not have practical significance since the disconnecting means hp rating for the full load current value is larger than this locked rotor value. The code in Section 4403b (new Section 430-110b) requires that the rating be based on the larger of the two values obtained.

The full load current rating in this case is the larger of the two ratings so its value of 15 hp would be used for the disconnecting means rating.—B.Z.S.—5/59/2

Transformer Vault Construction

Q. *If a person wishes to install a transformer vault in the basement of a new home or small business building (about 25 kva to 50 kva load) what are the requirements for the vault and the underground primary? The plan is to install 15,000-volt cable and operate it at 4160 Y for the present. How would the cost of this cable (about 100 ft) compare with the cost of about 120 ft of 250 M.C.M. RH-RW wire?—R.E.*

A. The construction of a transformer vault is covered by Section 4542 of the code. An exception however is made by Section 4523-a when the total kva capacity is not over 112½ kva. Under such conditions the vault may be constructed of reinforced concrete not less than 4 ins. thick. Other pertinent provisions covering doorways, ventilation, drainage, etc. are covered by Sections 4543 through 4548. Reference to Section 4542 further indicates that forms of fire resistive construction, other than specified, may be used provided they have adequate structural strength for the conditions and a minimum fire resistance of two and one-half hours according to ASTM Fire Test Standard E119. The quality of the material used in the construction shall be of a grade approved by the inspection authority having jurisdiction.

Code provisions covering the underground primary service to the transformer vault are covered by Section 2387, and the primary disconnecting means and overcurrent protection is covered by Sections 2388 and 2389 respectively. Here again an exception to the code rules

30th. Anniversary
1929 1959

ELECTROMODE
LEADER IN ALL-ELECTRIC HEAT

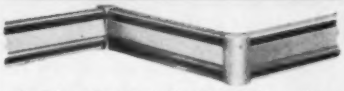
30 YEARS of SAFETY!

That's the record attained by Electromode. The foundation of this exclusive safety principle is the Safety Grid heating element, a finned aluminum casting with all electric wires completely sealed inside. It has become famous through the years for its positive protection against fire, shock or burn.

Today, Electromode heaters are made in more than 100 different models for:

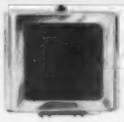
HOME • INDUSTRY • FARM

ELECTROMODE BASEBOARD ELECTRIC HEATERS



Spread radiant warmth along outer walls, under windows and across floor. Controlled by room thermostat. Completely flexible to room design.

WALL-TYPE FAN-CIRCULATING AUTOMATIC HEATERS



Quick, Economical Heat for Bathroom or Small Room

Down-flo Heater for Big Rooms

ELECTRIC INSERT DUCT HEATER

for PACKAGE AIR CONDITIONING UNITS

Made in 2 models: DH-3, 3KW and DH-5, 5KW; 240 volts, single or 3 phase.

SUSPENSION-TYPE UNIT HEATERS

10 to 45 KW
34, 150 to 153, 675 btu

Portable Models Also Available

NOTE TO CONTRACTORS

In designing these heating systems, Electromode had the contractor as well as the user in mind.

- EASY TO INSTALL
- SATISFIED USERS
- NO CALL BACKS
- PROFITABLE LINE TO HANDLE

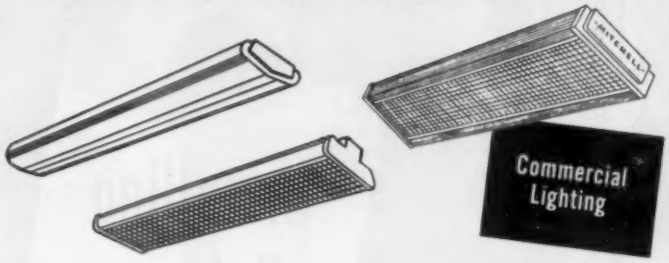
All your requirements from one reliable source

▶ *Write for complete information*

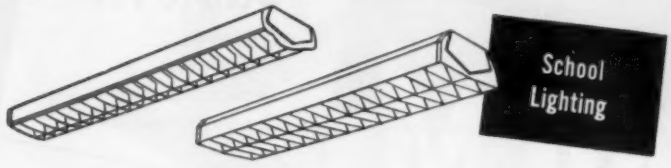
ELECTROMODE
division of Commercial Controls Corp.
Dept. ECM-59, 570 Culver Road
Rochester 3, N.Y.

MITCHELL *Specify The Most Dependable Name in Lighting!*

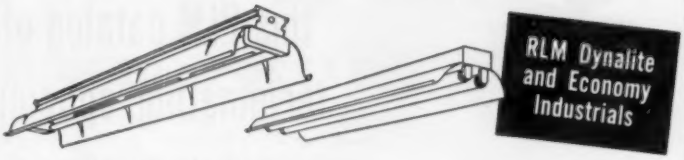
A Complete Line for Every Specification...Every Job!



Commercial Lighting



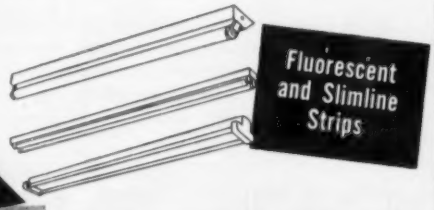
School Lighting



RLM Dynalite and Economy Industrials

Mitchell Lighting Company gives you the finest design and engineering in Fluorescent Lighting. Established more than 25 years ago Mitchell Lighting experience in design, engineering and manufacturing is your guarantee of quality lighting equipment made by a dependable organization.

EASIEST TO INSTALL ***UNI-FLOW*** Fluorescent Troffers



Fluorescent and Slimline Strips

MITCHELL

MITCHELL LIGHTING COMPANY

DIVISION OF COMPCO CORPORATION

1802 North Spaulding Avenue • Chicago 47, Illinois • U.S.A.

this PLM catalog of terminating, splicing and ventilating accessories can save time and money!

Don't let terminating or splicing problems hold up needed cable installations! You can find correctly designed answers to them, fast, from PLM — whether your requirements call for standard or special items.

PLM Catalog 301 lists more than 1200 standard types and sizes of terminators, splices, conduit ventilators and unit package kits for making splices and terminations in cable installations through 23 kv. Speed up planning, ordering and installation. Write for your copy today. PLM Products, Inc., 3875 W. 150th St., Cleveland 11, Ohio.

PLM Terminators Splicing Kits Conduit Ventilators

is made when the vault is under the sole control of the supply company.

In view of the many variables which enter the picture, and in the absence of specific details, it is difficult in any article of this nature to give a definite answer to your question. I know from experience however that the electrical utility, the local inspector and the insurance carrier are concerned with such a primary installation, and they should be consulted before any action is taken.

Since the cost of materials is beyond the scope of "Questions on the Code," I would suggest that you contact a local electrical supply house for the cost of the materials involved with a primary or secondary service.—B.A.McD.—5/59/3.

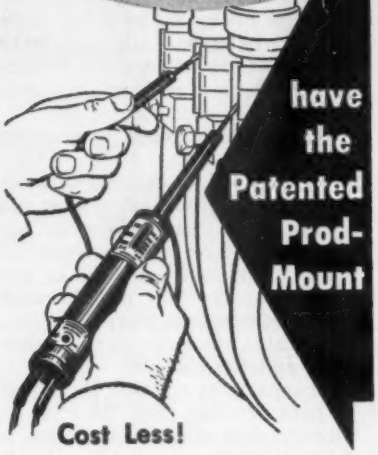
Non-Metallic Sheathed Cable Supports

Q. 1—*Is it the intent of Section* 3362-*a of the NEC to permit non-metallic cable to be run in the voids of concrete block walls without supporting the cable within* 12 *ins. from every outlet and at intervals of* 4½ *ft as required by Section* 3363? *Section* 3363 *states that the cable shall be secured with "approved staples, straps or similar fittings." Some interpretations to this requirement conclude that a box can be placed in a concrete block wall and the cable run in the voids of the wall without securing the cable. (Refer for instance to illustration in Segall's Electrical Code Diagram.)*

The situation with NMC cable is a little different (Section 3362-*b). It can be assumed that this cable can be embedded in masonry as it is not specifically stated that it cannot be as it is for NM cable in paragraph (a). The NMC cable could be embedded in the mortar between the blocks and would then be essentially secured, however not with "staples, straps or similar fittings" as stated in* 3363.

Q. 2—*In connection with this same type of wiring method Paragraph* 3707 *states that boxes shall be held in place by concrete, masonry or other building materials in which they are "embedded." In laying up a concrete block wall sections are cut out of the blocks and the switch boxes installed after the wall is up by pulling the cable through the voids in the wall. The boxes are grouted in with a cement and sand mixture. It seems that there is the possibility of the box*

You can
treat 'em Rough
- the Reliable
KNOPP
Voltage Testers
can "take it"



have the Patented Prod-Mount

Cost Less!

You don't baby the Knopp Voltage Testers. They're built to withstand the shocks of rugged daily use.

To save your time in testing you get the original patented Prod-Mount in the housing, making this tester easier and safer to use. You get the safety of dual indication of voltage by solenoid and neon lamp working independently. The scale readings are positive. Signal is by hum and vibration. Insulated for maximum protection.

It tells quickly if the circuit is open or closed; magnitude of voltage between 110 and 600 a-c or d-c, pure or rectified; 25 to 60 cycles.

The Knopp Voltage Testers have won fame from coast to coast among engineers, electricians and power companies. So why pay more for a tester when the Knopp Voltage Tester gives you more features and more value at less cost.

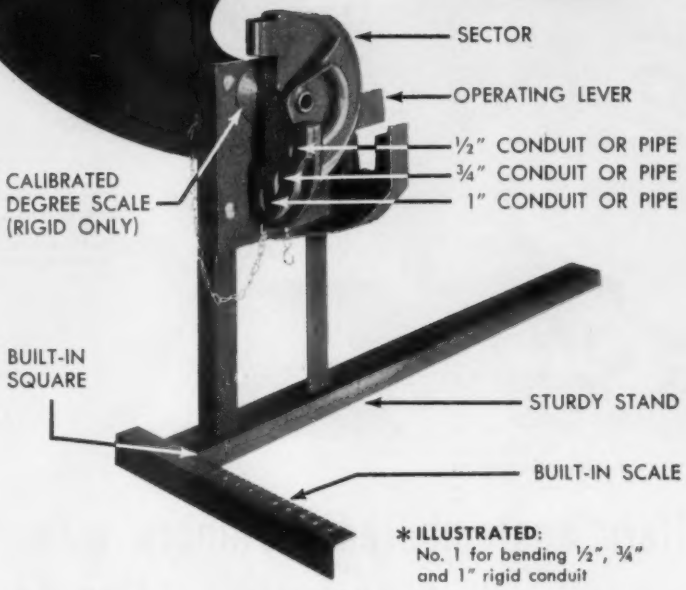
There are two models to choose from; pick up one at your dealer today or write for illustrated, free descriptive Bulletin No. 425.

The KNOPP Phase Sequence Indicator
60 v. to 600 v.; 25 to 60 cycles; Rotating Indicator shows sequence A-B-C or C-B-A. Lightweight. Compact. Big time-saver.

KNOPP INC.
Founded in 1928 by Otto A. Knopp under the name of Electrical Facilities Inc.

Dept. A-3
1307 66th Street Oakland 8, Calif.

BEND CONDUIT EASILY and ACCURATELY with a real on-the-job tool!



* ILLUSTRATED:
No. 1 for bending ½", ¾" and 1" rigid conduit

RUGGED...PORTABLE...SIMPLIFIED

These are complete machines of all steel construction and their light weight (*66 lbs. including stand) make them a real on-the-job tool. There are no loose parts to be misplaced or lost and the only maintenance is an occasional drop of oil. You get accurate bends every time . . . no strain, slipping or loose parts to worry about. Benders work equally well on aluminum or steel conduit. Ask the electrician who is using one; he will tell you it's the finest tool available and at a price that is eminently reasonable.

BENDING CIRCLES: INSIDE RADIUS

	No. 1	No. 1T
½" conduit or pipe	2"	EMT 3"
¾" conduit or pipe	4¼"	EMT 4½"
1" conduit or pipe	5¾"	EMT 6½"
	No. 2	**No. 2T**
1¼" conduit or pipe	7¼"	EMT 9½"
1½" conduit or pipe	8¾"	EMT 10½"

Write for FREE Illustrated Folder on How to Bend Conduit

LIDSEEN OF NORTH CAROLINA, INC.
1050 FIRST STREET, HAYESVILLE, NORTH CAROLINA
PHONE HAYESVILLE 2000

ONLY RAMSET

A single Ramset fastener holds 3-ton truck
Spring-like action of compressed steel surrounding the fastener creates a vise-like bond, developing amazing holding power

Ramset holding power test conducted by The Austin Co., engineers and builders, Cleveland, Ohio

offers austempered fasteners with such superior holding power

Even under the most demanding workloads, Ramset's austempered Red-Tip fasteners assure more holding power and greater fastener strength. Austempering, Ramset's high-heat slow-quench treatment, puts extra strength, toughness and dependability into every Ramset Red-Tip fastener.

Ramset's wide variety of fastener sizes puts the *right* fastener on each job—you don't have to "make-do" with off-size pins or studs. Ramset assures positive, guaranteed fastenings into tough steel, concrete or masonry faster and easier, and at lower in-place cost. Consider Ramset's many advantages and the "100-for-100" guarantee—call your Ramset dealer (under "Tools" in Yellow Pages) for details.

In addition to powder-actuated fastening, the versatile Ramset System includes Shure-Set® hammer-in tools for light fastening, and Ringblaster® heavy-duty kiln gun.

Ramset® Fastening System

WINCHESTER-WESTERN DIVISION • OLIN MATHIESON CHEMICAL CORPORATION
12105-E BEREA ROAD • CLEVELAND, OHIO

working loose in time. Would this grouting-in of the box meet with the code requirements for "embedded" or would the boxes have to be installed as the wall is laid up?

It is interesting to note that the requirements of Section 3343 for armored cable do not require securing when the cable is fished. Was this intended to include cables installed in concrete block walls?—F.D.

A. 1. For the benefit of our readers, Section 3362-a reads in part as follows: Type NM cable "may be run or fished in air voids in masonry block or tile walls when such walls are not exposed or subject to excessive moisture or dampness."

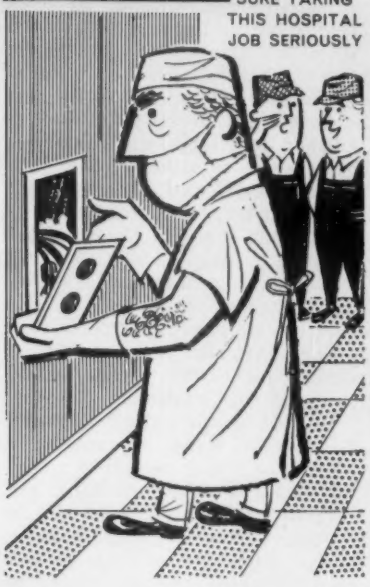
Section 3363 reads in part as follows:

"Cable shall be secured in place at intervals not exceeding 4½ ft and within 12 ins. from every outlet box or fitting, except that in concealed work in finished buildings or finished panels for prefabricated buildings where such support is impracticable, the cable may be fished from outlet to outlet."

It appears to me that the intent of both of these rules is to recognize the fact that when a cable is fished through a concealed space, it is impracticable to support such a cable as provided under Section 3363. In fact it would be impossible to do so without removing sections of the building finish, and to do so would eliminate the desirable feature of fishing the cable from outlet to outlet. On the basis of hazard, there appears to be no concern. Many of us recall the days when our old houses were wired for electricity. We recall the "artisan" electrician who could wire an old house with cable or flexible conduit with very little disturbance to outside finishes. The art of fishing, by an expert in those days, was an achievement for which we have just reason to be proud. There is however a distinction in hazard between the wiring of a new house and an old one. In the first case, the wiring is installed during the construction period. It is exposed to injury by the various mechanics involved, who are not particularly concerned with the electrical installation. Under such conditions, it is essential that cables be supported. When cables are fished, they are not exposed to exterior mechanical injury and the occasion for support is minimized. I believe Mr. Segall's diagram correctly illustrates the intent of the code on this question, and I also believe that the many thousands of

CONDUIT QUIPS

ALGIE IS SURE TAKING THIS HOSPITAL JOB SERIOUSLY

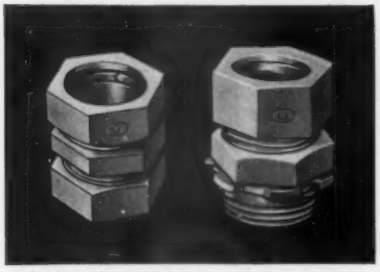


But problems with fittings are no joke

Just a burr that isn't properly removed — or a chewed-up thread in a fitting can really get a fellow steamed up on the job. We take a lot of time and painstaking care at Conduit Fittings to make sure your time isn't wasted. So when you need the finest, call on Conduit for fittings.

Write for Free Catalog

E.M.T. Compression Fittings



Compression Type E.M.T. Connectors and Couplings. Approved raintight—concrete tight. Accurate machining insures proper seating of the compression ring and a secure fit on the tubing.

usi Conduit Fittings

DIVISION OF U.S. INDUSTRIES, INC.

6400 West 66th Street, Chicago 38, Illinois

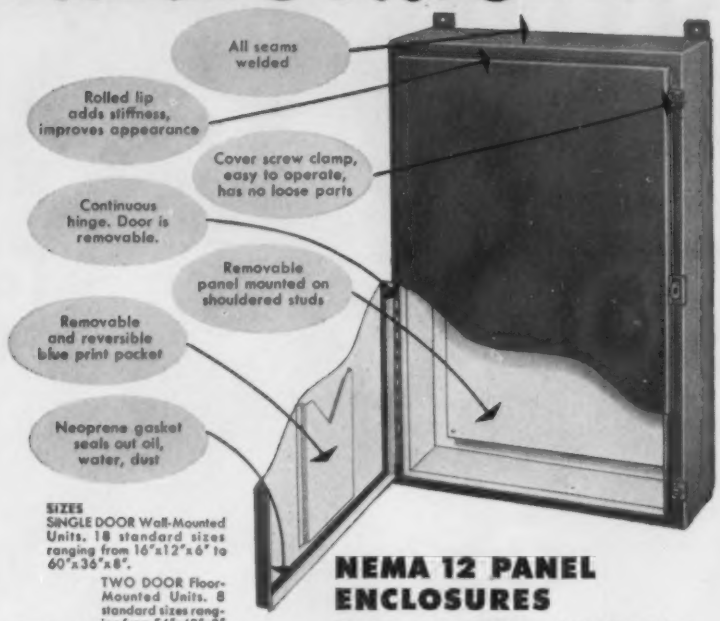
CHAMPION
of the four major brands of lamps
CHAMPION
stands out for
VALUE
Light/per/dollar . . . the measure of value in lamps . . . delivered in full measure by Champion lamps . . . sound reason for choosing Champion's as your company's best buy.
CHAMPION Lamps
Incandescent
Fluorescent
Your best buy in lamps

CHAMPION LAMP WORKS, Lynn, Massachusetts

OIL-TIGHT and DUST-TIGHT

ELECTRICAL ENCLOSURES

Standard sizes immediately available from stock


All seams welded
Rolled lip adds stiffness, improves appearance
Cover screw clamp, easy to operate, has no loose parts
Continuous hinge. Door is removable.
Removable panel mounted on shouldered studs
Removable and reversible blue print pocket
Neoprene gasket seals out oil, water, dust

SIZES
SINGLE DOOR Wall-Mounted Units. 18 standard sizes ranging from 16"x12"x6" to 60"x36"x8".

TWO DOOR Floor-Mounted Units. 8 standard sizes ranging from 54"x42"x8" to 72"x60"x12".

NEMA 12 PANEL ENCLOSURES

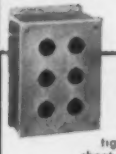
These handsome units are ideal for housing electrical controls, terminal strips and control instruments. Strong, rigid, welded construction. Neoprene gasket on door protects against dust, dirt, oil, water. No knockouts or screw holes. Units are frequently used in purged or pressurized systems for installation in flammable or dust-laden atmospheres. Standard stock sizes, one door and two door units. Fast delivery. Made of 10, 12 and 14 gauge sheet steel. White baked enamel interior, gray prime coat exterior.

Stocked and sold by leading electrical distributors

NEW STANDARD CONTROL CONSOLES

Designed especially for industrial use, these cabinets offer the same oil-tight and dust-tight advantages that feature "Hoffman" enclosures. Our standard 14 gauge steel units, shipped from stock, save you design expense and delivery time. Sloping control panel is removable so you can drill holes for pushbuttons, etc.

An additional upright instrument panel as well as handy writing desk can be added if desired. All units have interior sub-panels. All doors and panels gasketed. Standard size is 23"x17"x40", or we can build to your specifications.



PUSH-BUTTON BOXES
Oil and dust-tight. 14 gauge sheet steel. 38 sizes in 4 types—Standard, Extra Deep, Slim, and Pendent. Made to take from 1 to 25 pushbuttons of any make.

JIC WIRING BOXES
Welded seams, no knockouts or screw holes. 8 sizes. Gasketed cover. 14 gauge sheet steel. Gray hammertone finish. Panel optional.

SECTIONAL WIREWAY
Protects electrical wiring from oil, water, dust. Gasketed joints and cover. Comes in 1 to 10 foot straight sections, with all fittings. Sizes: 2½", 4" and 6" square.

Send for catalog with complete specifications for your layout work. We can also build special enclosures to your specifications.

Hoffman
ENGINEERING CORPORATION
Dept. ECM-123, ANOKA, MINNESOTA, Phone HArrison 1-2240

old buildings that have been wired by fishing is evidence of the safety of such procedure. The only thing that I see fit to criticize with respect to Section 3363 concerns the last clause which reads as follows:

"Cable shall be secured in place —except that in concealed work in finished buildings—the cable may be fished from outlet to outlet."

The definition of an outlet would not include a box containing a switch. As a result, you could fish between outlets, but you could not fish between an outlet and a switch, or between boxes containing switches which occurs when 3- and 4-way switches are involved. I doubt however that such a restriction ever was intended.

Insofar as the Type NMC cable is concerned, it may be embedded in plaster, or it may be run in a shallow chase in masonry walls, and covered with plaster as covered by Section 3362-b. It cannot however be embedded in poured cement, concrete or aggregate as covered by Section 3362-c. Under such conditions of use, it appears to me that the support provisions of Section 3363 should be satisfied before the plaster is applied. I do not believe that we should depend solely upon the plaster to hold the cable in place.

A.—2. The provisions of Section 3707-a state that an outlet box, unless *securely held* in place by concrete, masonry or other building material in which it is embedded, shall be secured to a stud, joist etc. The words in italics anticipate the condition which you have described. A box which is inserted in an opening of a concrete block is not in my opinion embedded in masonry and I do not believe that a thin mortar used to fill the spaces around the box (grout) fully satisfies a literal reading of the rule. I believe that a supplementary means of support should be provided. It is interesting to note that wooden supports shall be not less than ⅞ in. in thickness, and that a lathe of wood is not considered to be an adequate support. This provision emphasizes the importance of obtaining a support which satisfies the first sentence of Section 3707 which reads as follows: "Boxes, fittings and cabinets shall be securely fastened in place."

Mr. Whitner, Chairman of Panel No. 7, has expressed the following opinion with respect to the support of boxes as covered by Section 3707-a:

"I agree that boxes fastened or grouted in place in the concrete block wall with lime mortar or plas-

Latrobe *Electrical* Products

TRU LEVEL FLOOR BOX

The No. 190 Tru-Level is a fully adjustable, 4" galvanized octagon watertight floor box, developed for concrete or tile floors, also wooden floors with concrete base.

A ½" threaded adjusting-ring and three 2½" long screw legs make for quick and easy tru-leveling. A rubber collar protects the adjusting ring thread.

The octagon box body is 2½" deep with two ½" and two ¾" K O's in sides and three ½" and two ¾" K O's in bottom. This series permits "on-the-job" interchangeability with the various new standard styles and sizes of receptacles.

Listed under re-examination service of Underwriters Laboratories, Inc.

Write today for complete specifications.

Visit Our Booth #423—NAED Convention, Chicago, May 24-27

Non-Adjustable Watertight Floor Box

Unique, practical design cuts installation time; makes safer job and leaves more wire space inside box. Cover plate is 3½" diameter.

Insulator Supports

Fasten porcelain or glass insulators to steel framework without punching holes. 4 sizes —1",1½",2" and 2½".

Latrobe Products

Non-Adjustable Floor Boxes
Adjustable Floor Boxes
Gang Boxes—Cover Plates
Junction Boxes—Nozzles
Pipe or Conduit Hangers
Insulator Supports
Cable Supports—Fish Wire
Staple and Cable Clips

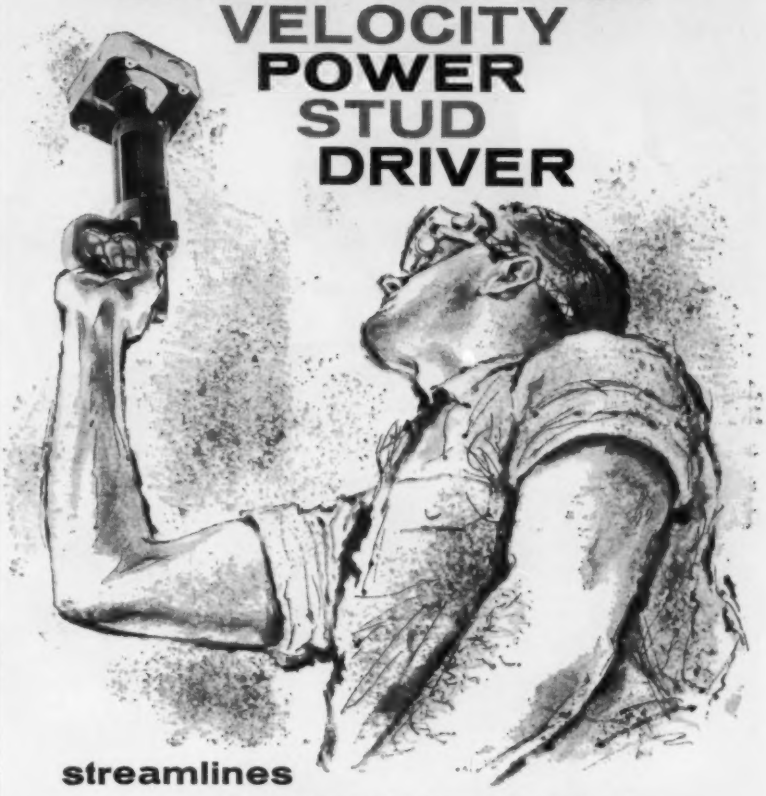
Sales Representatives in all principal Cities.

Fullman Manufacturing Co.

1209-1215 JEFFERSON STREET

LATROBE, PA.

NEW "GREEN HORNET" VELOCITY POWER STUD DRIVER



streamlines electrical fastening jobs speedily • safely • inexpensively

Now you can save precious time and energy on those tiresome, time-consuming electrical fastening jobs.

The "Green Hornet" Velocity Power Stud Driver fastens conduit and raceways securely, in seconds. Lets you anchor outlet and junction boxes rapidly, accurately, safely, with lots less elbow grease than called for in manual installations.

Shaking hands with the pistol grip of the "Green Hornet" is the beginning of straight, firm stud driving at a fraction of the time and money it's costing you now. Operation is so simple: just load stud and cartridges, lock breech with 180° barrel turn, position. Then press and fire. This is fastening: the twentieth century way.

Wide variety of studs—threaded or plain-headed—are available.

Interchangeable barrels accommodate ¼- or ⅜-inch diameter studs for handy two-tools-in-one convenience. Pressure controlled firing eliminates accidental discharge by dropping. Safety is the big consideration here.

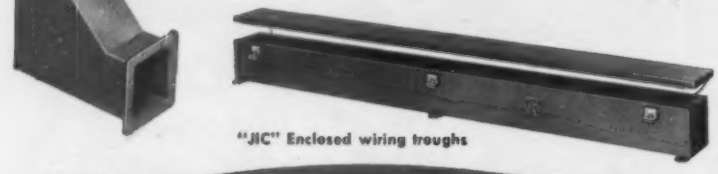
Further mechanized fastening features include: trigger activation, protective safety shield, pistol-grip handle, quiet operation. Maintenance is easy. Design is compact.

See for yourself. Ask for a demonstration. And write us for Bulletin 1411-2.

VELOCITY-POWER TOOL COMPANY

201 North Braddock Avenue • Pittsburgh 8, Pennsylvania

"JIC" Wireways and auxiliary fittings

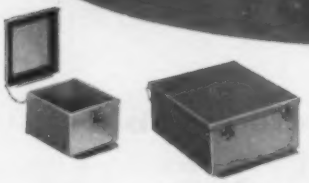


"JIC" Enclosed wiring troughs

It pays to figure on

KEYSTONE

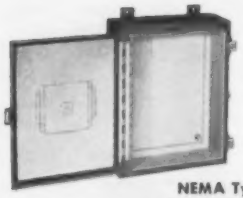
liquid-tight "JIC" wiring enclosures



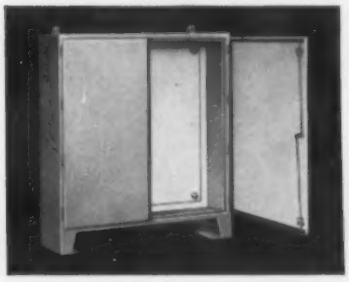
"JIC" Terminal and Pull Box Enclosures

Keystone now offers a complete line of "JIC" wiring enclosures designed to provide positive, sealed protection against dust, dirt, oil, water and coolants! You'll find liquid-tight wireways, fittings, troughs, boxes and cabinets in a wide range of sizes to meet your exact needs—all produced to the electrical specifications of the Joint Industry Conference Standards.

What's more, when you *want* an item, you *get* it—*fast*—from large stocks maintained at both factory and regional warehouses! In addition, Keystone offers a complete design and build service for producing custom enclosures to fulfill your special requirements!



NEMA Type 12—"JIC" Control Panel Enclosures



Oil-Tight Pushbutton Enclosures

3 NEW CATALOGS—Contain complete information on the entire Keystone quality line. Send for your free set today!

KEYSTONE MANUFACTURING COMPANY

23338 Sherwood Avenue • Warren, Michigan

tic would not be considered substantial, but if the box is grouted in with a cement and sand mixture it would seem to me that such a mixture would harden to the equivalent of the box being embedded in cement or concrete, and should furnish satisfactory support."—B.A.McD.—5/59/4

NEC Official Interpretations

The Electrical Correlating Committee of the National Fire Protection Association has reviewed and released the following two interpretations of sections of the 1956 National Electrical Code. Effective date is February 9, 1959.

Subjects covered by the release are: the use of a green insulated conductor on secondary wiring of fluorescent lamp fixtures; and arrangement of switches operating panels of cartridge fuses protecting elevator control equipment.

Official text of the new interpretations follows:

INTERPRETATION NO. 451
SECTION 2112—Color Code

Statement: In an installation of fluorescent lamps, the secondary wiring from the ballasts to the lampholders in the fixtures utilizes a conductor with green insulation. The wiring is entirely confined by the fixture enclosure and is not connected to the circuit wires supplying the fixture.

Question: Is the foregoing use of green insulation contrary to the second paragraph of Section 2112 of the 1956 Code?

Answer: No.

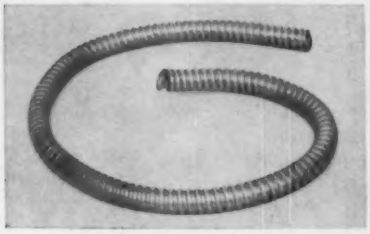
INTERPRETATION NO. 453
SECTIONS 2440 and 6261—Disconnection of Fuses and Guarding Equipment

Statement: Elevator control equipment protected by cartridge fuses is located in a separate machine room having self-closing, self-locking doors, expected to be kept closed and locked except when an attendant is on duty. There are a number of separate panels with cartridge fuses installed in the room and individual switches are not installed in each circuit ahead of the cartridge fuses. Instead each panel is controlled by a separately mounted, manually operable switch located in the control room. Each switch is within sight of the panel which it controls.

Question: Does the foregoing arrangement comply with the intent of Sections 2440 and 6261?

Answer: Yes.

INTERNATIONAL Electrical Conduit



Finest Quality—Lowest Prices

International Metal Hose, one of the nation's largest producers of flexible metal conduit and tubing, utilizes modern equipment and automated processes to produce superior products at competitive prices. Ask International to quote your needs and compare price, quality, and delivery.

INTERNATIONAL SEALED SKIN
LIQUID-TIGHT FLEXIBLE STEEL CONDUIT
(J. I. C. Approved)

Strong, flexible metal core for simple, fast installation even in "U" bends and crowded quarters. Special polyvinyl cover is liquid-tight, abrasion-resistant, and provides permanent protection against oil, grease, weather, water, dirt, chemicals, fumes, and salt spray. Sealed Skin's Flexibility is especially adapted to providing connections between a moving member and stationary part and for resistance to vibration. It is easily cut to required lengths on the job. Made to meet Joint Industry Conference (J.I.C.) requirements. Packaged in a handy "playout" carton.

INTERNATIONAL U. L. & C. S. A. LABELED
FLEXIBLE STEEL CONDUIT

Made to Underwriters' and Canadian Standards Approval—meets all the rigid tests for flexible metal conduit conducted by Underwriters' Laboratories, Inc. Rust-resistant zinc coating gives longer protection against corrosion, dirt, fumes, spray, and superior finish "dresses up" installations. Automatic degreasing gives oil-free conduit. Special built-in flexibility makes installation easier—resists vibration—flexes into "U" bends—follows machine or installation contours. Especially adapted for connections between moving members and stationary parts. Comes in easy-to-handle coils tagged with Underwriters' and C.S.A. Label.

INTERNATIONAL EXTRA FLEX
FLEXIBLE STEEL CONDUIT

Lower cost conduit for use where U.L. type is not necessary. Gives extra flexibility with economy, provides unexcelled, low-cost, crush-resistant shielding for floor, wall, ceiling cables. Electroplated to give rust-resistant zinc coating. Superior finish "dresses up" installations. Automatic degreasing gives oil-free conduit. Easy to install—resists vibration—flexes into "U" bends and to follow machine or installation contours. Available in easy-to-handle coils.

INTERNATIONAL LIGHTWEIGHT
FLEXIBLE STEEL CONDUIT

A sturdy, lighter-weight flexible steel conduit at lower cost. Available in a wide range of sizes for most every need. Economical to use and to ship.

Send for specifications and price list

THE INTERNATIONAL METAL HOSE CO.
BELLEVUE, OHIO

ONLY TWO PIECES TO INSTALL
. . . and both Light-Weight

WITH GARCY "ULTRA-LUX"
Curved diffuser in 12" or 24" widths

OR 60TH ANNIVERSARY
Rectangular diffuser in 12" or 24" widths

It's a snap to install these Garcy fixtures. Only two basic parts to install, that's all. No on-the-job assembly work. End plates, diffuser panels and hinge fittings are all pre-assembled for you before shipment.

And Garcy fixtures are easy to handle. Even a lightweight like the gal above could handle these compact fixtures all day without tiring.

Find out for yourself how much on-the-job time you can save with Garcy fixtures.

Send for Bulletins 581-L and 582-L.

GARCY LIGHTING

division of Garden City Plating & Mfg. Co.
2475 Elston Ave., Chicago 47, Illinois

CHICAGO • NEW YORK • LOS ANGELES • TORONTO

SAVE UP TO 35% WITH

TELEC-CON

PLASTIC CONDUIT

. . . a most *versatile, dependable* and *economical* conduit for electrical and communication lines, single or multiple duct installations, underground or underwater!

YOU CAN SAVE UP TO 35% on installation costs, and *eliminate* most maintenance problems, with lightweight, water-tight and corrosion resistant TELEC-CON, available in *four* types, 2" to 6" diameters.

Send for complete brochure, and name of your nearest supply point.

Southwestern
PLASTIC PIPE CO.
P. O. Box 117 • Mineral Wells, Texas Phone FA 9-3344

In the News

Technical Training Stressed at Power Conference

Approximately 3,000 engineers, industrial and public utility executives, educators, and government officials attended the 21st annual American Power Conference held in Chicago, March 31 and April 1 and 2. The three-day conference is sponsored annually by the Illinois Institute of Technology in cooperation with 14 other educational institutions and nine professional societies.

Norman J. Cutliff, general foreman, electrical department, International Harvester Co., Memphis, Tenn., talking on the training of plant electricians said: Various plants of his company regularly employ a variety of training methods to meet the diversification of their production. But generally, these methods fit within a pattern based on important needs. He cited the needs:

1. Qualified employees who are competent to perform the requirements of their respective jobs and to fully develop their potential and so provide effective and proficient service.

2. Constant economic awareness by those responsible for training plant electricians.

3. Strict compliance with all national, state and local electrical code requirements.

4. Constant training in sound industrial safety practices.

5. An effective means of insuring that plant electricians are kept current with changes inside the plant and the addition of new equipment.

6. Electrical supervision accepting the principle that they must constantly be both learner and instructor in this training program.

M. A. Jacobs, A-C Spark Plug Division, General Motors Corp., Milwaukee, Wis., speaking on the importance of electronic training programs, said: "Since 1955 over three hundred men from nearly all of the divisions of General Motors Corp. have been trained on company time. These men were sent by their divisions to Flint, Michigan, to participate in this program. The philosophy of the program was to provide these men with a thorough background in the basic principles of electronics. A second objective of the course was to provide a good comprehension of the uses and limitations of typical pieces of test equipment. A third objective of the course was to relate the basic principles of electronics to the particular pieces of equipment in their respective plants."

The course consisted of a total of 80 hours of which 40 were spent in class and 40 in the lab. Jacobs pointed out the lack of consistency in the backgrounds of the men sent to the school by the various divisions. He said some of the people sent to the school were graduate engineers; others were electricians with little more than bulb-changing experience. In some of the classes it was necessary to take time to make up for a deficiency in basic electricity. But they were able to, in nearly all cases regardless of background, and due to constant use of test instruments, at least partially fill the need for training electronics people in industry. Jacobs stated "however they were often able to use the better informed to assist the less informed in the laboratory, much to the advantage of both."

Chicago Holds Industry Show

The fifth biennial Electrical Industry Show sponsored by Chicago's Electric Association in cooperation with the Electrical Maintenance Engineers was held at the Hotel Sherman, Tuesday, Wednesday, and Thursday, March 24, 25, and 26.

The show devoted strictly to the "electrical man" attracted over 217 manufacturers who exhibited the latest in electrical construction materials and industrial equipment.

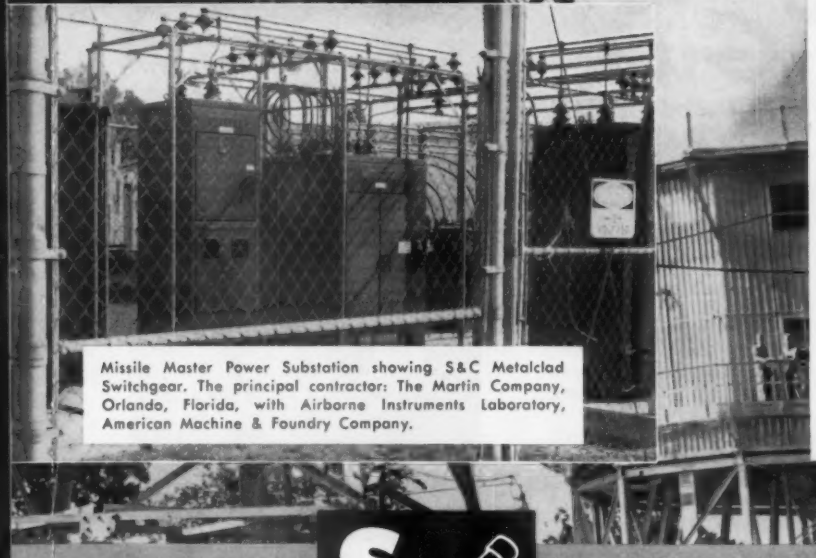
On Wednesday morning, March 25, hundreds of apprentices, engineering and technical students visited the show between the hours of 10:00 A.M. and 1:00 P.M.; with the latter part of the day from 1:00 to 10:00 P.M. being set aside as Electrical Maintenance Engineers Day. Electrical Contractors Day was held on Tuesday, March 24th.

Exhibits included products for use in electrical construction, industrial and commercial electrical installations, electric welding, electronics, industrial appliances, and commercial and industrial lighting. The show excluded all home appliances and domestic applications of electricity.

For the U.S. Army Missile Master—

Where Reliability is a Command:—

S&C Metalclad Switchgear is used on the primary power supply



Missile Master Power Substation showing S&C Metalclad Switchgear. The principal contractor: The Martin Company, Orlando, Florida, with Airborne Instruments Laboratory, American Machine & Foundry Company.

At Fort George G. Meade, Maryland, this vital electronic installation collects information on the location of aircraft, presents this information on displays for decision, and then distributes selected data to NIKE missile batteries in a large defense area. The high-voltage power supply for the radar and electronic devices uses S&C Metalclad Switchgear for primary protection and switching.

Specified as part of this ultra-reliable nerve center of the Nation's defense are S&C Metalclad Switchgear units, using Power Fuses and Load Interrupters. See inset, left.

Such installations will be used in many areas throughout the United States, where NIKE installations protect population and industrial centers.

For further information about S&C Metalclad Switchgear, write to S&C Electric Company, 4433 Ravenswood, Chicago 40, Ill.

Specialists in High-Voltage Circuit Interruption for Utilities Since 1910

S&C

METALCLAD SWITCHGEAR

Handle HOT jobs the SAFE way!

DON'T

use a steel fish tape and spend many dangerous hours snaking it through a conduit.

DO

use a Jet Line Gun and safely jet-propel a nylon line through the conduit in seconds!

NOTHING BEATS

THE *Jet Line Gun*

For SAFETY and SPEED!

The Jet Line System is SAFE!

- No powder charge
- No explosion
- Both nylon line and polyethylene rope are non-conductors.

The Jet Line System

SAVES WIRE!
SAVES MONEY!
SAVES TIME!

Invented by experienced electricians . . . in use by thousands of contractors!

Do away with danger!

There's no need to worry about hot panels when you use a Jet Line Gun . . . because the need for fish tape and snaking is eliminated!

A small jet-propelled cartridge does the trick! Launched by the Jet Line Gun, in seconds it twists around ells and bends, up and down as it lays a nylon line in the conduit . . . draw polyethylene rope through and you're ready to pull wire in minutes, not hours . . . *safely!*

Ask your distributor or write

Pat. Pending on Method and Apparatus

Jet Line Gun Company

730 Seigle Ave., Charlotte, N. C.

3759

Copyright 1958 Jet Line Gun Co.

N.Y.C. to Refund Contractor License Fees

A court decision has declared illegal the $250 license renewal fee imposed by the City of New York on electrical contractors and at least $100,000 and possibly much more must be returned to the contractors.

State Supreme Court Justice Aron Steuer said the city had no right to charge such high fees on the theory that the money was needed to help pay for regulating the electrical industry and providing for inspections.

"The inspections," he said, "have nothing to do with licensing. They are for the purpose of protecting the city's inhabitants from the dangers attendant upon inferior workmanship . . . equally necessary whether the artisans doing the work were licensed or not."

The decision resulted from a suit brought by members of the Five Boro Electrical Contractors Association, which represents small contractors holding master electrician licenses, against the city and its Department of Water Supply, Gas and Electricity which issues the licenses. The suit attacked the fee as excessive, unreasonable and discriminatory and asked that the fees in excess of $25 be refunded.

The estimate of the amount to be refunded is based upon only those contractors who have paid fees under protest. If all the city's 2,200 licensed electricians were to recover their payments in excess of $25 over several years, the amount would approach $2,000,000.

The fee, originally $25, was raised to $100 in 1952 and to $250 in 1957.

THREE-MAN FORUM at Chicago inspector's meeting rehash Code "toughies" between sessions. Pictured (L to R) are Everett Cogan, International Secretary, IAEI; H. Bernhard, Chicago Inspector; and William Veldhouse, Chicago Contractor.

Headquarters for HIGH POTENTIAL Testing

INSULATION BREAKDOWN DIELECTRIC STRENGTH

Every over-potential test need from the generator to the appliance motor . . . is met by a HYPOT®

150 KV Testing Mobile HYPOT®

Non-destructive testing of power cables, generators, and insulators with AC or DC test potentials to 150 KV. New DC Mobile HYPOT® is easier to handle, cuts costs. Write for bulletin "Mobile HYPOT®"

Model 5500

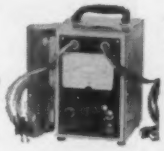
Typical Mobile HYPOT® provides 0 to 120 kv d-c at 5 ma. More compact and easier to use than equivalent a-c test sets. Lower in cost, too.

30 KV Testing Bench HYPOT®

Models available with AC or DC test potentials from 5 to 30 KV. Widely used for insulation testing of cables, distribution equipment and heavy duty motors.

10 KV Testing Portable HYPOT Jr.®

The advanced over-potential tester that enables anyone to make high potential breakdown tests. Separate lights indicate excess leakage current and insulation breakdown. Available with test voltages from 1500 v a-c to 10000 v a-c.



Model 412

Output 0 to 1500 v, a-c. Indicator lights for insulation breakdown and excessive leakage current.

Only . . . $137.50

VIBROGROUND measures GROUND RESISTANCE SOIL RESISTIVITY

Ground Resistance Only

VIBROGROUND® Models 251 and 255 provide push-button direct reading measurement from self-contained power supply (two No. 6 drycells). No cranking or leveling. Rugged steel case measures 6"x9"x8½". Weight is 17 lbs.

Model 251 . . . ground resistance ranges are 0-12.5/125/1250 ohms. Only.....$120.50

Model 255 . . . ground resistance ranges are 0-3/30/300/3000 ohms. Only.....$142.50

Soil Resistance . . Anode Resistance Ground Resistance

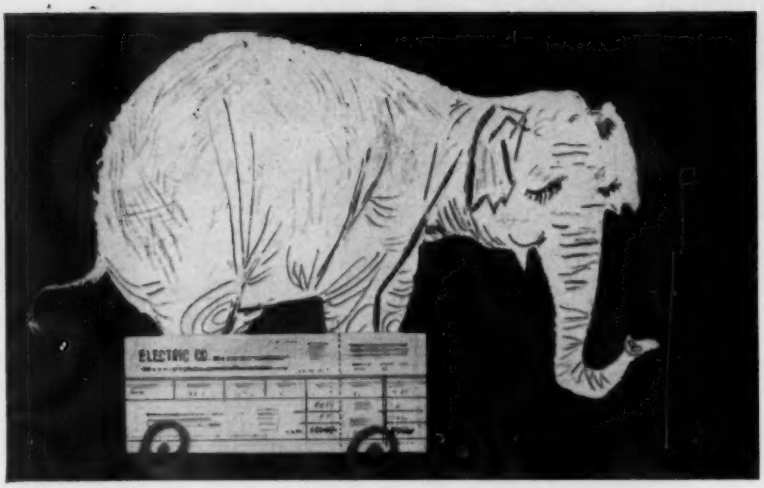
VIBROGROUND® Model 263A requires no cranking or leveling. Push-button direct reading measurement of soil resistivity, circuit resistance, anode resistance and polarization. Ranges are 0-1/10/100/1000 ohms. Heavy duty steel case is 9"x6"x6½". Weighs 10 lbs.

Only . . . $152.50

Write for bulletin . . "VIBROGROUND®". 10-35.15

ASSOCIATED RESEARCH, Incorporated

3770 W. Belmont Avenue • Chicago 18, Illinois



THE ABOMINABLE WHITE ELEPHANT ON YOUR ELECTRIC BILL

IF YOUR ELECTRICAL SYSTEM is burdened with a low power factor, you're paying for electricity you can't use . . . you're giving up electrical capacity you may need.

The motors and other inductive devices in your plant use both kilowatts (working current) and kilovars (magnetizing current) in order to run. The kilowatts you buy. The kilovars you can best supply yourself. *The more you supply, the higher your power factor, and the less you pay the electric company.*

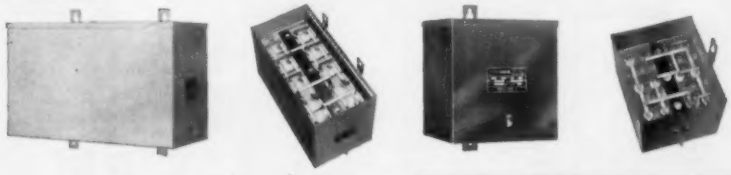
Sprague Unipak* Power Factor Correction Capacitors are the most economical and efficient means of supplying your own kilovars. You put them right where they're needed . . . *at the motors.* Your electric company does not have to send as many kilovars all the way from the power plant, so they charge you less. Your wiring does not have to carry the extra kilovars to the load, so it can handle additional loads.

Actual power bill savings experienced in many plants have more than paid for the Power Factor Capacitors in less than a year's time . . . in some cases, in less than six months. And as an added dividend, these capacitors have also increased the power handling capacity of many plant distribution systems by an average of 20%.

You, too, can reduce costs . . . increase your plant's electrical capacity by installing Sprague Unipak Power Factor Correction Capacitors.

If you'd like *free* assistance in making a survey of your electrical installation to see how *you* can save money with Sprague Unipak* Power Factor Capacitors, write Industrial Capacitor Division, Sprague Electric Company, 333 Marshall Street, North Adams, Massachusetts.

*Trademark



WORLD'S LARGEST CAPACITOR MANUFACTURER

SPRAGUE®

the mark of reliability

PVC ROYALOK

Caps and Connectors interlock with a twist of the wrist . . . give you rugged, positive, fail-proof power connections.

Unbreakable molded vinyl bodies—can't crack, chip, or break . . . hold blades and contacts solidly in place. Resistant to acid, oil, and grease.

Safer, stronger construction— Dead-front caps eliminate nuisance of fiber washers and dangers of exposed conductors. Internal barriers separate conductors. One-piece connectors have heavy brass double-wipe contacts locked in solid vinyl.

ORDER FROM YOUR WHOLESALER, OR WRITE FOR CATALOG 2-58-4.

QUICK, CLEAN WIRING 3 Simple Steps!

1. Remove cord grip plate by loosening plate screws (they can't fall out).

2. Insert cord thru clamp, strip conductors and connect to terminals.

3. Replace grip plate, tighten screws — that's all!

A Broad Line of ROYALOK Interlocking* Devices

2-Wire Polarized	3-Wire Polarized Grounded	4-Wire Grounded
10 Amp — 250V 15 Amp — 125V 20 Amp — 250V Dead-front caps . . . one-piece connectors	10 Amp — 250V 15 Amp — 125V 20 Amp — 250V 10 Amp — 600V Dead-front caps . . . one-piece connectors	20 Amp — 250V 10 Amp — 600V Dead-front caps . . . one-piece connectors

*Fit all standard interlocking devices

ROYAL ELECTRIC

. . . an associate of

ROYAL ELECTRIC CORPORATION
PAWTUCKET, RHODE ISLAND

P. R. Committee Announced by NEMA

The National Electrical Manufacturers Association has concluded a year of study of its responsibilities to its membership and the electrical industry by establishing a standing Public Relations Committee to work toward improving internal Association communications and its relations with allied "customer" groups.

Members of the committee are Donald Jensen, Chairman, Director of Public Relations, Square D Company; K. W. Haagensen, Director of Public Relations, Allis-Chalmers Manufacturing Company, Milwaukee; Dale McFeatters, Vice President, Information Services, Westinghouse Electric Corporation, Pittsburgh; and R. H. Smith, Secretary, Reliance Electric and Engineering Company, Cleveland.

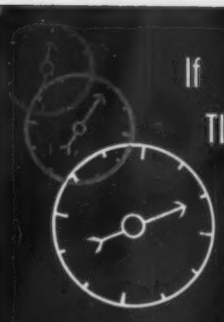
Electrical Maintenance Men Convene in Los Angeles

A 3-day conference was staged by the Electrical Maintenance Engineers Association of California, March 24-26, in Los Angeles, with some three dozen speakers and panel members discussing future as well as present problems facing this important segment of industry and commerce. In addition, conference delegates had the opportunity to inspect a concurrently-held exhibit of electrical products displayed by 50 sponsoring manufacturers.

During this intensive interval, six main topics of interest were stressed: the Code; Control and Automation; Industrial Power Systems; Maintenance of Electrical Equipment; Modern Lighting; and the Estimating of Additions and Expansions.

General chairman for this sixth annual conclave was William E. Cline of the General Electric Co., while the six panels were presided over by Low Pascoe, G.E.; Richard L. Somer, Federated Engineering; Emerson S. Reichard, Electrical Engineer; Barney Shrive, Kaiser Steel; Urban Beh, consulting Lighting Engineer; and Charles Hays, president of the Electrical Estimators.

Also active on the conference committee were Frank J. Rohring, Southern California Edison; Walter J. Collins, L. A. Dept. of Water and Power; E. J. Grassie and James A. Marshall, both from G.E.; these men being responsible respectively



If TIME Figures In Your PROFITS -

Your wisest choice is the . . .

ARROLET

Non-Gangable

SWITCH BOX

New line-up guides help you install box easier, quicker and more accurately.

—other top features:

- Slotted cable knock-outs lift out clean and easy.
- Square corners allow more wiring room.
- Available with brackets.

—an excellent box for your next job. Write for specification sheet.

Quality Needed for Tomorrow is in Arrolet Products . . . *Today!*

SWITCH BOXES
OUTLET BOXES
BOX COVERS FITTINGS

ARROLET
CORPORATION
Montgomery, Penna.

Sales Representatives & Warehouse Stocks® BALTIMORE, MD. • *CHICAGO, ILL. • *CINCINNATI, OHIO • DALLAS, TEX. • GREENSBORO, N. C. • *KANSAS CITY, MO. • *LOS ANGELES, CALIF. • *MIAMI, FLA. • NEW YORK, N. Y. • NEWTON CENTRE, MASS. • *PHILADELPHIA, PA. • *RICHMOND, VA. • ROCHESTER, N. Y. • *SEATTLE, WASH. • *TAMPA, FLA.

MULTI

DEPENDABLE LIGHTING EQUIPMENT ALWAYS

MULTI RLM

QUALITY PORCELAIN ENAMELED REFLECTORS

ALUMINUM REFLECTORS ALZAK FINISH

MULTI QUALITY THROUGH THE YEARS INSURES CUSTOMER SATISFACTION

PREFERRED BY THE ENGINEER • WHOLESALER • CONTRACTOR • MAINTENANCE

SEE OUR CATALOG IN SWEET'S ARCHITECTURAL FILE OR WRITE FOR COPY

FOR COMPLETE CATALOG ADDRESS REQUEST TO

YOUR GUIDE FOR DEPENDABLE LIGHTING EQUIPMENT

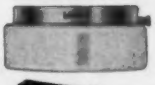
RLM INCANDESCENT REFLECTORS
WHITE PORCELAIN INSIDE, OUTSIDE THREADLOK PENDENT OR BOX MOUNTING SOCKETS • COMPLETE RANGE OF SIZES & SHAPES

RLM HIGH BAY REFLECTORS
ALUMINUM WITH ALZAK FINISH. STEEL WHITE PORCELAIN ENAMEL 300 TO 1500 WATT INCANDESCENT OR 400 W. OR 1000 WATT MERCURY VAPOR NARROW BEAM, MEDIUM OR WIDE SPREAD

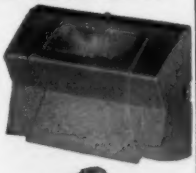
VAPORPROOF FIXTURES
CAST ALUMINUM HOUSINGS PORCELAIN ENAMELED REFLECTORS 100 TO 500 WATT SIZES. PENDENT BOX OR BRACKET MOUNTING CLEAR, HEAT RESISTING GLASS

GYMNASIUM FIXTURES
FOR SUSPENDED CEILING MOUNTING SERVICEABLE FROM ABOVE OR BELOW 500 WATT—18" PORCELAIN ENAMELED REFLECTOR. ALSO AVAILABLE WITH CAST ALUMINUM GUARD

CEILING FIXTURES WITH HINGED GLOBE. FIVE SIZES, ALUMINUM FITTER



HOSPITAL ROOM-BED FIXTURES
INCANDESCENT DUAL LIGHT CAST ALUMINUM. DESIGNED TO GIVE MORE LIGHT WHERE NEEDED VENTILATED FOR COOLER OPERATION

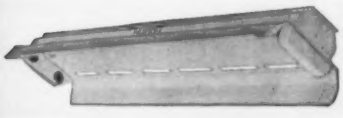


FLOODLIGHTS
ALUMINUM WITH ALZAK FINISH WITH HINGED HEAT RESISTING LENS. ALSO AVAILABLE IN OPEN TYPE, ANGLE, ELLIPTICAL AND STEEL PORCELAIN ENAMELED.

SPARLITES-LAMPHOLDERS
FOR PAR 38—R40-PAR 56 LAMPS. COMPLETE LINE OF BOXES, FITTINGS, LENS AND ACCESSORIES.

PARKING AREA POST LIGHTS
500 WATT PORCELAIN REFLECTOR WITH SPARLITES

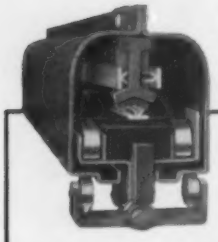
RLM FLUORESCENT FIXTURES



MULTI
ELECTRIC MFG. INC.
4237 W. LAKE ST. CHICAGO 24

4 EQUALLY GOOD REASONS

...why your cranes and hoists should be FEEDRAIL® powered



Throughout industry, flexible Feedrail systems, in capacities from 60 to 500 amperes, provide convenient movable power sources for:

- Cranes and Hoists
- Production Lines
- Conveyor Assembly Lines
- Moving Test Lines
- Portable Tools
- Machine Tools
- Cutting and Sewing Rooms
- Lighting
- Motor Control

1. **Safe electrification.** Feedrail conductors are protectively enclosed in steel – no exposed wiring, no trailing cables. You enjoy maximum protection for personnel and equipment.

2. **Minimum maintenance.** Elimination of frayed, sagging, broken wires means safer, less frequent maintenance.

3. **Better materials handling.** There are no time consuming traffic holdups with Feedrail. Fewer accidents, less maintenance mean absolutely minimum down time – more efficient materials handling.

4. **Lower operating costs.** Elimination of hazardous, wasteful working conditions not only leads to better performance but improves safety records and plant morale as well – eventually lowers insurance costs too.

A Feedrail "moving power system" will fit your crane or hoist's needs – can be installed quickly and easily. Get full information. Write today to Dept. C-5.

SOLD BY MORE THAN 1,000 ELECTRICAL DISTRIBUTORS FROM COAST TO COAST

TS

Never Becomes Obsolete

ELECTRIC FEEDRAIL®

FEEDRAIL CORPORATION

Subsidiary of Russell & Stoll Company, Inc.

125 BARCLAY STREET • NEW YORK 7, N. Y.

SPECIALLY QUALIFIED REPRESENTATIVES IN PRINCIPAL CITIES

for banquet, registration, exhibit and general arrangement details.

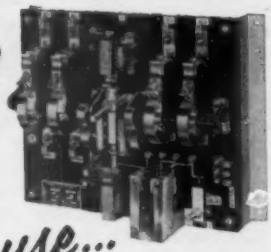
In the Code session, G. A. Wintz, Chief Electrical Inspector for the City of Los Angeles; Arthur C. Veit, Supervising Electrical Engineer in the Building and Safety Division of the County Engineer, and Edward V. Muller, Industrial Safety Engineer for the State of California, collectively urged adoption of a uniform, single code that would govern all types of construction and areas, thereby eliminating the several conflicts of interpretation that presently exist between various city, county and state ordinances. Revision of code recommendations was also urged on the grounds that constantly mounting local values were being complicated by a more compact arrangement of equipment, conduits, ducts, busways and controls, resulting in reduced clearance distances, less maintenance space, less circulation of air, higher ambient temperatures and poorer operating conditions.

Considerable discussion was also directed to the intelligent selection and use of higher utilization voltages, the grounding of portable equipment, the acceptance of interlocked armor cable for voltages both above and below 5000 volts, the installation of aluminum conduit underground, variations in current-carrying ratings between State Safety Orders and the NEC, the use of trolley-duct casing as a neutral, the importance of IC ratings of breakers, the emphasis upon pressurization of instruments and electrical equipment in hazardous areas, explosion-proof fittings for MI cable.

A total of nine panel members covered the gamut of control and automation from short circuit protection and control components to static control devices, heating and ventilating control, ac eddy-current variable-speed equipment and new adjustable-speed dc drives. Panel members for this discussion included Electrical Engineers William Fayer, Ed York and Howard Gluckman, also Electrical Engineering Associate H. L. Holland; all from the Dept. of Water and Power, City of Los Angeles; plus John H. Tuttle, sales engineer for Cutler-Hammer; King D. Christopher, general manager of Clark Controller's Los Angeles manufacturing division; Max D. Polling and Carl Boehmer, district engineers for Louis Allis, and W. R. L'Hommedieu, applications engineer for ITE Circuit Breaker.

The second day of the conference

FOR *POWER* THAT'S ALWAYS ON THE JOB



use...

ZENITH

AUTOMATIC TRANSFER SWITCHES

Zenith Automatic Transfer Switches assure full protection against *any* failure of regular voltage. Transfer to emergency power in a fraction of a second is automatic at 70% of line voltage. Regular power is restored at 90% of line voltage.

Simple design . . . sturdy construction . . . switches lock mechanically through trouble-free toggle action . . . no springs, latches or delicate mechanisms.

Available electrically or mechanically held, 30 to 600 amps.

Send for free catalog on complete Zenith line.

ZENITH ELECTRIC CO.

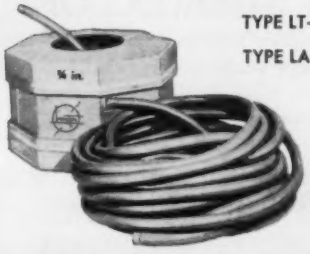
155 WEST WALTON STREET • CHICAGO 10, ILL.

All the installation speed of Flexible Conduit . . . All the protection of Rigid Conduit . . . with

LIQUATITE®

Extruded Polyvinyl Jacket Molded to Galvanized Flexible Conduit

Complete protection against any and all contamination—impervious to water, oils, chemicals, corrosive atmospheres. Installed in minutes. No more "down-time" due to wiring shorts or burn-outs, no more periodic wiring replacements.



TYPE LT—JIC Approved

TYPE LA—Underwriters' Approved

Write for free sample, costs and name of Distributor nearest you.

ELECTRI-FLEX COMPANY

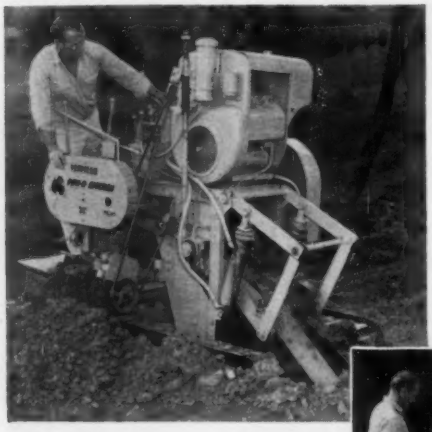
P. O. BOX 128-C • ROSELLE, ILLINOIS

Answers the need for a Sturdy, Strong Staple. Save Time, Labor, Material with these rugged Thiel Staples.

Sold by Leading Electrical Wholesalers
Send for FREE Samples

THIEL TOOL AND ENGINEERING COMPANY

1417 N. Market St. • St. Louis 6, Mo.



Which Size For YOU?

Rugged, Inexpensive Vermeer

POW-R-DITCHERS

Looking for low-cost, time-saving trenching and ditching? Take a look at the full Pow-R-Ditcher line before you buy!

Write For Complete Information, Literature and Low Prices

The model 4T (left above) digs 6" to 14" wide and the W-2 (right above) digs 2½" to 4" wide. (The larger 524T model digs up to 24" wide.) All are fast, rugged, self-propelled and low in price. Ideal for digging foundation footings, gas, water and sewage lines . . . or for shallow, narrow service lines.

VERMEER MANUFACTURING COMPANY

1460 W. WASHINGTON PELLA, IOWA

CLOCK and PROGRAM SYSTEMS *MUST HAVE . . .*

● MAXIMUM RELIABILITY

Cincinnati's Signa-Link programming, enclosed snap-action switches and precise construction give utmost reliability.

● LOW INITIAL COST

No finer system for any price. Check Cincinnati's low cost for your next job.

● EASY INSTALLATION

Cincinnati's swing-out trunnion mount and plug/receptacle mounting secondaries provide installation speed and ease.

● LOW MAINTENANCE COST

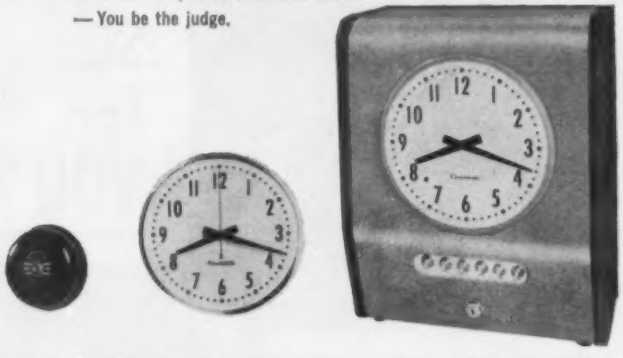
Cincinnati's rugged construction with no costly components assures inexpensive, easy maintenance.

● U.L. APPROVAL

Cincinnati equipment is U.L. approved.

● ATTRACTIVE APPEARANCE

Illustrations speak louder than words.
— You be the judge.



Add easy schedule setting, wide correction range and the widespread, efficient Cincinnati service organization, and you have customer satisfaction at its most satisfying. Write today for descriptive literature and the name of your local Cincinnati representative.

CINCINNATI SYSTEMS
THE Cincinnati TIME RECORDER CO.
CINCINNATI 14, OHIO
SINCE 1896

covered Industrial Power Systems and the Maintenance of Electrical Equipment.

In the first of these two sessions, Robert N. Marcum, plant engineer for Hughes Aircraft at Fullerton reviewed Large Industrial Systems, using as his main illustration a recently-completed plant where outside consultants had been retained for initial load studies, system design, utility services, budgets, maintenance planning and provisions for future expansion.

Discussing electrical systems in smaller plants, W. D. Bonzer, engineer and assistant superintendent for the Larson-Hogue Electric Co., reviewed trends based upon his company's experience in plants having fewer than three maintenance men and having voltages not exceeding 4160 volts.

Colonel F. Snyder, Division Electrical Engineer for Albert C. Martin & Associates, architects and engineers, reviewed west-coast trends in the design of electrical systems for large (commercial) buildings.

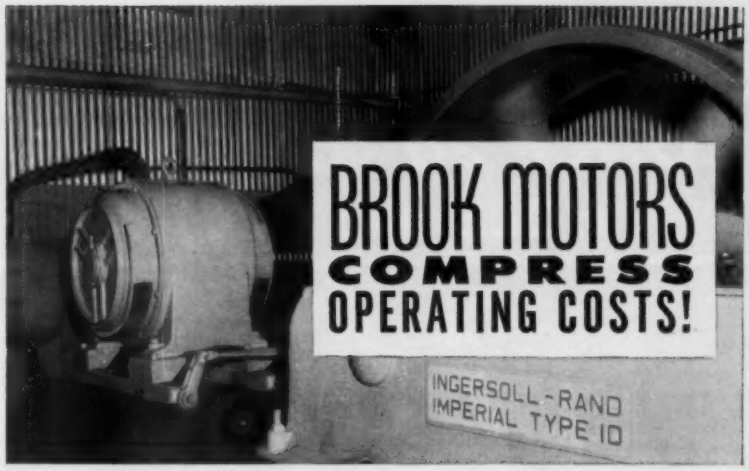
The third day featured two more panel discussions on Modern Lighting and Estimating Additions and Expansions for existing structures.

Urban Beh, consulting lighting engineer, discussed fundamentals of lighting, while Edward Balogh, chief lighting engineer for Sunbeam, analyzed various methods for calculating obtained footcandle levels. Modern lighting values were reviewed by Robert S. Clubley, industrial lighting specialist for General Electric, while Frank H. Martin, technical director for Pittsburgh Plate Glass, used an effective chart presentation to prove that "There's More to Color than Meets the Eye." Roy E. Bevan, district engineer for Sylvania, covered the importance of lighting maintenance.

At the sixth and final session, Charles H. Hays, president, and Henry F. Hopkins, vice president, of the Electrical Estimators, Inc., together with Paul Diederick, president of the Olympic Industrial Electric Co. of Los Angeles, presented a no-holds-barred session on Estimating. In this final presentation of the 3-day conference, actual case-studies of typical electrical additions were considered step-by-step, and estimates were formulated wherein symbol lists and floor plans were utilized, conduit was wheeled off, components were chalked off and toted up, labor units were estimated, allowances were made for a variety of reasons and conditions, overhead was discussed, supervision and travel time analyzed.

PRECISION Engineered Fittings

M. STEPHENS
Mfg. Inc. Los Angeles 11
814 E. 29th St. ADams 1-9147



Users report savings on operating costs when BROOK A.C. MOTORS furnish power for compressors, pumps, conveyors and machinery in factories, mills and mines. Brook Motors require less maintenance. There is no finer motor built, yet they *cost less.* All standard enclosures, including NEMA Rerates. 1 to 600 H. P. Warehouse stocks, factory representatives and dealers coast-to-coast. Send for literature.

SINCE 1904 BROOK MOTOR CORPORATION

world's most respected motor

BROOK MOTOR CORPORATION
3302W. PETERSON AVE., CHICAGO 45, ILL.
In Canada: Brook Electric Motors of Canada, Ltd.
250 University Ave., Toronto, Ontario

Best for Insulation Test!

"MINOR" MEGOHMER

SMALL SIZE
LOW PRICE

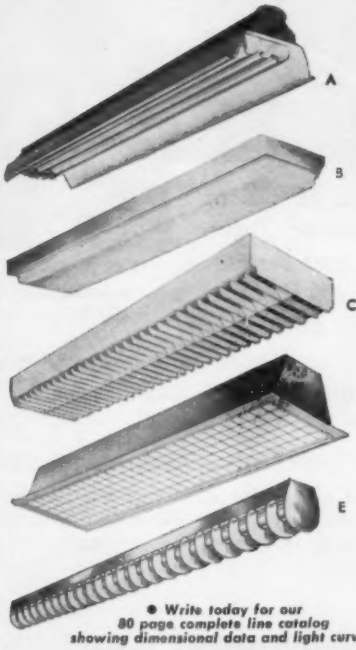
DEEP CASE
EASY CRANKING
with 500 VOLT DC GENERATOR

Range 0-50 Megohms; weight 3 lbs. True Ohmmeter, independent of generator speed. Complete with genuine leather carrying case, 6 ft. test leads, 50 Megographs.

WRITE FOR BULLETIN NO. 450

HERMAN H. STICHT CO., INC.
27 PARK PLACE, NEW YORK 7, N. Y.

FOR THE FINEST IN LIGHTING—SPECIFY GOOD



Engineered for Greater Efficiency, Appearance and Maintenance

GOOD offers the most comprehensive, versatile and uniform line of quality fluorescent fixtures. Their wide variety, both in width and length, provide the fullest choice of high efficiency recessed lighting units for stores, offices, schools, institutions and other installations of every type.

A Few of the Many Models To Choose From

A. Industrials — Many types and sizes available for various industrial applications.

B. Geometrics—Available in all popular sizes, surfaced or recessed. Your choice of many shielding medias.

C. Commercials—Available in many designs. See catalog for complete commercial selections.

D. Troffers—Available in all shielding medias.

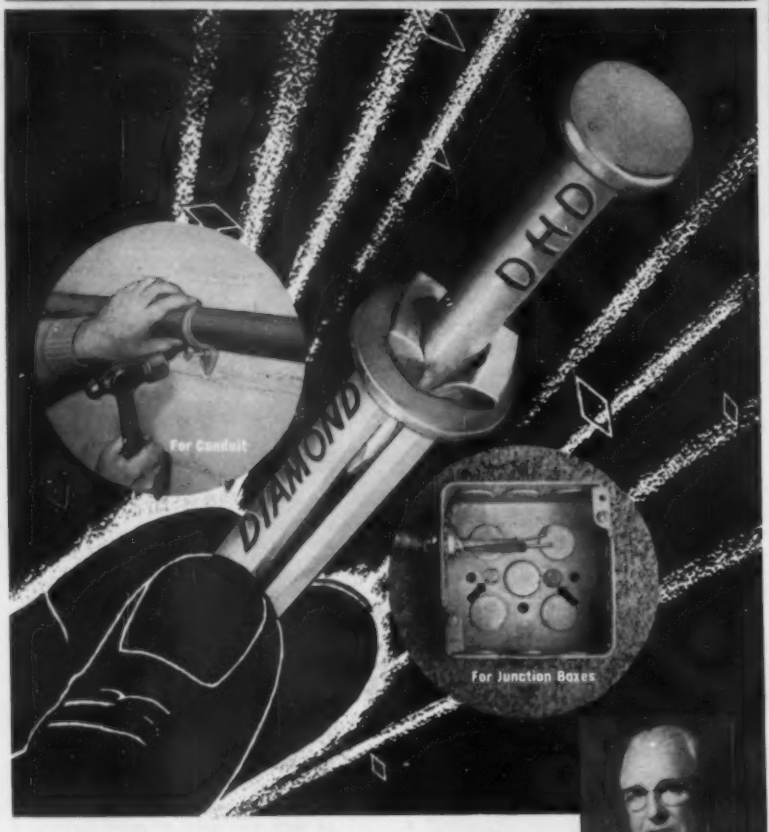
E. Corridor Luminaires — Available in metal baffles or plastic enclosed.

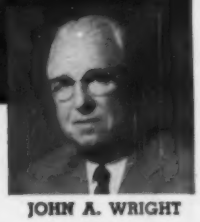
● *Write today for our 80 page complete line catalog showing dimensional data and light curves.*

GOOD MANUFACTURING CO., INC.
1015 N. Halsted Street
Chicago 22, Illinois

DHD®

"ONLY 20 SECONDS* HOLE and ALL..."





JOHN A. WRIGHT
Vice President

is all it takes to ANCHOR into BRICK or CONCRETE with DHD® Hammer Drive Anchors. They are SAFE, fast and secure. The smallest size holds 500 to 700 lbs. For use indoors or outdoors. Sizes available from *3/16" x ⅞" to ½" x 3½". Would you like to try a few samples, free? Just drop me a note." John A. Wright, Vice President.

WHERE TO BUY DHD® HAMMER DRIVE ANCHORS . . .

ONLY thru your wholesaler, whose stocks of all Diamond Anchors enable you to get fast delivery service. This policy plays an important part in your ability to get contracts done faster and profitably.

*(*3/16 x 7/8 size. Installed hole and all!)*

DIAMOND EXPANSION BOLT CO., INC.
GARWOOD, NEW JERSEY

BRANCHES: Atlanta, Boston, Chicago, Dallas, Denver, Detroit, Los Angeles, New York, Philadelphia, Pittsburgh, San Francisco, Seattle, St. Louis, Washington, D. C., Montreal, Vancouver, Canada.

NISA News

Alexander T. Volland, owner of Volland Electric Equipment Co., Buffalo, N. Y., was elected president of NISA's Niagara Chapter at a meeting held recently in Rochester, N. Y. at the Hotel Sheraton. Other officers include Ralph Barker, Barker Electric Co., Niagara Falls, N. Y., vice-president; J. Clifford Nelson, Berger Brothers Electric Motors Inc., Rochester, treasurer; and Glenn T. Wardell, Wardell-Thurston Electric Co., Buffalo, secretary.

• • • •

Paul Duphily, Electrical Equipment & Maintenance Co., Milford, Del., was elected president of Quaker City Chapter at a meeting in Philadelphia on March 11. Richard Lehr, H. N. Crowder Jr. Co., Allentown, Pa., was chosen first vice-president; James Previty, Penn Electric Motor Co., Philadelphia, second vice-president; Milton Eisenhardt, who operates a motor shop under his own name in Pennsauken, N. J., treasurer; and George Wagner, Wagner Electric Service, Philadelphia; Joseph B. Roy, Roy's Electrical Service, Cheswold, Del.; Paul Secrest, S&M Electric Motor Repair, Trenton, N. J.; C. J. Allen, Hendrickson & Co., Philadelphia, Pa.; Clarence Chandler, McHugh Electric Co., Wilmington, Del.; and George McDaniels, Kufen Electric Motor, Hatboro, Pa., members of the executive committee.

• • • •

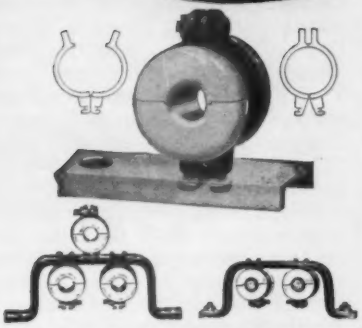
Earl Baker of Baker Electric Co., Denver, Colo. was elected president of Rocky Mountain Chapter at the organization's spring meeting at Continental Hotel, Denver. Gene Armstrong, Wazee Electric Co., Denver, was chosen secretary-treasurer. The club's next meeting will be held in Salt Lake City in the fall in conjunction with NISA's Utah Chapter meeting.

• • • •

Vernon B. Honsinger, engineer-in-charge of Allis-Chalmers' Norwood Development Laboratories, Norwood, Ohio, led off the program of Southeastern Chapter's annual spring technical meeting, held April 10-11 at Hotel Robert Meyer, Jacksonville, Fla. His topic was "Recent Developments in Insulation."

Other speakers during the two-day conclave included: Ronald P. Clark, wire and design engineer of Phelps-Dodge Copper Products Corp., Fort Wayne, Ind., who talked on "Compatibility of Class 'F' Magnet Wire"; Joseph T. Haughney, assistant director, Insulation Varnish

FOR QUICK, EASY
Cable Installation
"EFFICIENCY"
NESTED CONDUCTOR RACKS



Nested conductor racks are compact and scientifically designed to carry cables equidistant from center to center. Available in 2, 3, 4, 5 and 6 bushing racks.

EFFICIENCY
ELECTRIC & MFG. CO.
EAST PALESTINE, OHIO

Control Your
CARBON BRUSH
Inventory with
Handy-Kits and
Cabinets

HELWIG CARBON BRUSHES

Units have lifetime guaranteed See-Thru plastic drawers with moveable dividers. Both Handy-Kit and Cabinets complete with brushes for single phase motors, vacuum cleaners, mixers, fans, portable tools, etc. Units assure you have the right replacement stock on hand.

Write for Bulletin No. 65.

AVAILABLE NOW "RED CARPET" RUSH BRUSH SERVICE.

HELWIG CO.
CARBON PRODUCTS
2546 N. 30th ST.
MILWAUKEE 10, WIS.
HELWIG SPEER

---

when every point counts...

COUNT ON BERKO

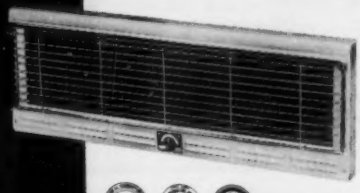
for the finest in glass electric radiant heating!

SAFE ALL OVER

No hot spots or danger points on the metal enclosures of any Berko unit. Its accessible areas are only slightly above body temperature.

THROUGHOUT U.S.A. & CANADA

Distributed everywhere by progressive electrical wholesalers. Dealers can avail themselves of quick service. Berko also maintains field engineers throughout the U. S. and Canada.



NEMA UL SA

BERKO ELECTRIC MFG. CORP.
212-40 Jamaica Avenue,
Queens Village 28, New York

BERKO

Leading manufacturers of glass radiant and convection electric heating

---

BUCHANAN

SPLICE CAPS and TERMEND® LUGS
in new smaller quantity
SLIP-TOP* BOXES

You will benefit from these outstanding advantages . . .

HANDIER—just shake out fittings as needed; eliminate counting out from larger packages.

MORE ECONOMICAL—eliminate spilling and other on-the-job wastage; simplify orders and inventories.

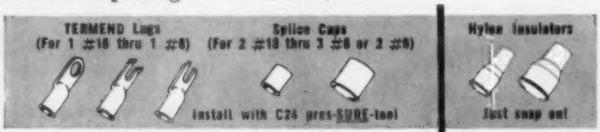
LESS INVESTMENT—buy or put out on the job only required number of packages of 50 or 100.†

† Small Splice Caps and Insulators 100/box; large Splice Caps, large Insulators and Termend lugs—50/box. (Insulators are packed in regular boxes.)

*An *exclusive* development of BUCHANAN

NOW IN STOCK AT YOUR ELECTRICAL DISTRIBUTOR

UL SA


TERMEND Lugs
(For 1 #18 thru 1 #6)
Splice Caps
(For 2 #18 thru 3 #6 or 3 #6)
Install with C26 press-SURE-tool
Nylon Insulators
Just snap on!

Write for Bulletin EC-5

In Canada
GASACCUMULATOR COMPANY (CANADA) LTD.
12 GOWER ST., TORONTO 16, ONT.
Export
PHILIPS EXPORT CO.
100 E. 42nd ST., NEW YORK, N. Y.

BUCHANAN
ELECTRICAL PRODUCTS CORPORATION
HILLSIDE, NEW JERSEY

TRADE ARRO MARK

MACHINE SCREW ANCHORS

Easy to install . . . requires shallow hole . . . fixture can be removed and replaced without loosening anchor . . . a few hammer blows set anchor firmly . . . conical-shape nut expands lead sleeve to provide strong holding power . . . widely used by electricians, plumbers, carpenters, ornamental iron workers, maintenance men, awning and sign men and other tradesmen.

Cutaway drawings show how setting tool expands lead sleeve around conical nut.

HAMMERLESS SETTING TOOL

Expander hammerless setting tool for easy installation of Arro Machine Screw Anchors in hollow tile, bottomless or weak-bottom holes.

THE TRADE ARRO MARK LINE OF MASONRY ANCHORING AND DRILLING DEVICES

See your industrial, hardware or electrical supplier

ARRO EXPANSION BOLT COMPANY

DEPARTMENT D, P. O. BOX 388, MARION, OHIO

Technical Service Department, Sherwin-Williams Co., Chicago, who discussed "Modern Insulation Varnishes"; D. M. Bartos, product development engineer of Dow Corning Corp., Midland, Mich., whose subject was "Silastic Insulation for Form Wound Coils"; NISA engineer A. C. Roe, who talked about "What Your NISA Can and Cannot Do for You"; Michael E. Assalone, manager, Florida Electric Motor Co., Miami, Fla., who reviewed "Small Motor Shop Practices"; and T. N. Schierloh, product service manager, Delco Products Division, Dayton, Ohio, whose talk was titled "The Future of Fractional Horsepower Motor Repairs."

Delegates also met in open discussion groups after the talks. Local shops visited included Jacksonville Armature & Motor Works, Florida Electric Motor Works and Turner Electric Works.

Officers of the Southeastern Chapter, who helped to arrange the meeting, were: T. K. Preddy, president; Lewis S. Bain, vice-president; and F. E. Cook, secretary-treasurer.

• • • •

Paul Sievert, president of NISA, was the opening speaker at the Brownsville, Tex., meeting of Southwestern Chapter, March 19-21 at El Jardin Hotel. His topic was "NISA, Present and Future."

J. Ray Horton, Daley Electric Co., Phoenix, Arix., discussed "Pricing, Costs and Profits"; and Darrell Hester, Harlingen, Texas, lawyer, spoke on "Legal Aspects of Business." "Rubber Silicon, Advantages, Application, Availability" was the topic of a talk by Donald M. Bartos of Dow Corning Corp., a speech subtitled "Silastic Insulation Systems Practical for Service Shop Fabrication." A representative of Allis-Chalmers, James F. Fenske, spoke on the subject "Modern Trends in Motor Designs and Applications". Edward Tann, Fluidwick Co., Detroit, reviewed applications of his firm's products.

A delegation of chapter meetings visited NISA shops in Monterrey, Mexico, after the meeting. Making the trip, where they were entertained during a round of luncheons and dinners and sightseeing tours by their Mexican hosts, were: Mr. and Mrs. G. E. Jones, G. E. Jones Electric Co., Amarillo, Texas; Mr. and Mrs. H. F. Champion, Service and Supply, Amarillo; Mr. and Mrs. Herbert Wilson, Southwest Electric Co., Oklahoma City, Okla.; Mr. and Mrs. O. H. Caldwell, Caldwell Electric Co., Waco, Texas; Mr. and Mrs. Frank Arriens, Frank's Elec-

Model 610 Metal Cutting Band Saw

MOUNTED on WHEELS

and Ready to GO!

The

KALAMOBILE

- **TRULY PORTABLE**
- **HANDIER THAN EVER**

The Kalamobile has rubber-tired wheels and telescoping handles . . . can be shifted from job-to-job by one man with ease. This new Mobile Model M610D cuts pipe and conduit fast and clean. Capacity 6" rounds . . . 10" flats.

Machine Tool Division

Kalamazoo TANK and SILO CO.

509 HARRISON ST., KALAMAZOO, MICH.

REPAIR FOR YOUR B&D TOOLS

For genuine Black & Decker repairs check Yellow Pages under "Tools-Electric" for address of nearby Black & Decker

FACTORY SERVICE BRANCH

Free tool inspection when requested • Genuine B&D parts used • Factory-trained technicians handle all work • Standard B&D Guarantee at completion of recommended repairs • Fast service at reasonable cost.

Or write for address of nearest of 48 branches to:
THE BLACK & DECKER MFG. CO., *Dept. S3105 Towson 4, Md.*

Black & Decker®
QUALITY ELECTRIC TOOLS

Jiffy NO KINK **FISH TAPE**

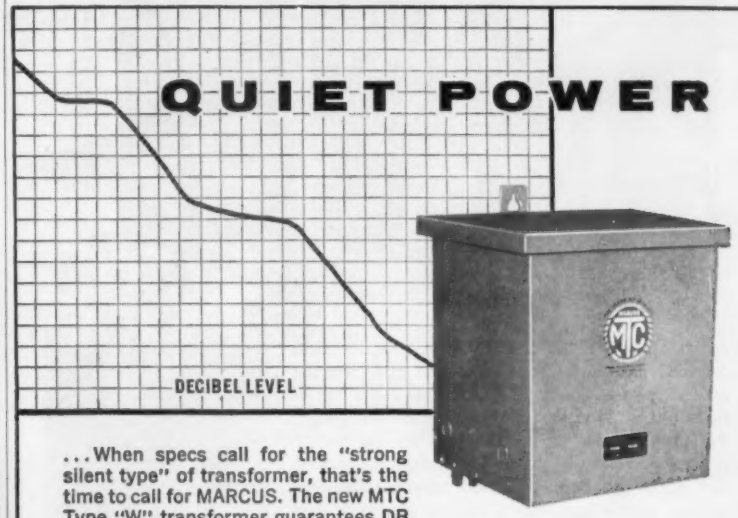
Designed for Aluminum Conduit.
•
Perfect for steel, too.

Jiffy **SLIP STICK**
(the wire lubricant in stick form), makes all wires really slip thru aluminum or steel conduit.

Write for complete Jiffy Catalog.

The Jiffy Line
Saves TIME TROUBLE MONEY
ESTABLISHED 1915
Clyde W. Lint
2323 W. 18TH STREET · CHICAGO 8, ILL.

QUIET POWER



...When specs call for the "strong silent type" of transformer, that's the time to call for MARCUS. The new MTC Type "W" transformer guarantees DB LEVELS THAT ARE BELOW NEMA STANDARDS. So for those extra quiet installations, Specify MARCUS---- Proven quieter by independent laboratory test.

- **LOWER SOUND LEVELS**
- **LOWER WEIGHTS**
- **LOWER INSTALLATION COSTS**

MARCUS TRANSFORMER CO., Inc.
RAHWAY, NEW JERSEY
"Mark of Quality"
Representatives in Principal Cities

A COMPLETE LINE OF DRY-TYPE AND LIQUID-FILLED TRANSFORMERS FROM 1 THROUGH 5000 KVA.

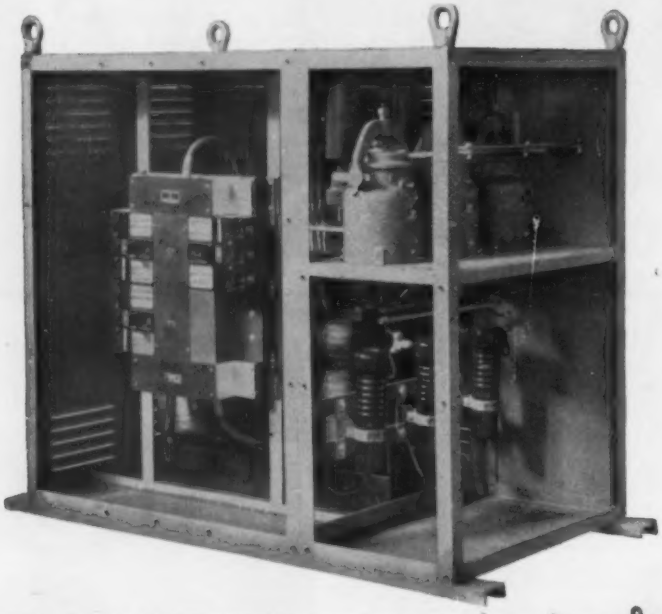
NEW!

LO-TEMP*

DISTRIBUTION UNI-CENTER

ECONOMY FOR CONTRACTOR . . . Convenient connection locations. Fully removable panels. Choice of components. Fast installation.

ECONOMY FOR USER . . . Extremely low copper losses. Added overload protection. No excessive voltage drops. DB level below NEMA standards.



New Standard DISTRIBUTION UNI-CENTERS combine incoming line, transformer and outgoing feeder in one compact unit. The 112.5 KVA, three phase, 4160 to 280y/120 is just 63½" high, 74" long and 36" deep. The high voltage section is equipped with three 3 KV lightning arresters and gang operated, oil fused cutouts. The low voltage section has 3-pole, thermal magnetic case circuit breakers. The unit is shipped, handled and installed in one piece. The Standard DISTRIBUTION UNI-CENTER is available in any KVA rating and to and including 4800 V.

*Standard LO-TEMP transformers provide extra capacity at no extra cost.

LIVE BETTER ELECTRICALLY

Standard Transformer CO.

Phone 2-1563

WARREN, OHIO

"WHEREVER THERE IS POWER"

tric Service, Bryan, Texas; Mr. and Mrs. George Kinard, Electrical Machinery & Repair, Beaumont, Texas; and J. B. Camp, Houston Industrial Supply, Houston, Texas.

• • • •

Oliver Klemp was re-elected president of Wisconsin Chapter at a meeting at Moonbi Inn, Germantown, March 17. Vice-Presidents are A. J. Kuzniewski and John Bickler. Secretary-treasurer is Jerry Miller. A new chapter member is Roland Wittenburg, R. J. Wittenburg Co. Speaker at the meeting was Arthur George, lawyer, who reviewed income tax laws.

• • • •

Paul Bogdan was elected president of Western Michigan Chapter at a meeting at the Anaconda Wire & Cable Co. plant in Muskegon, Mich., March 9. Other officers are: Stanley Stutsman, vice-president; and John Weeks, secy.-treas.

• • • •

Walter Leirer was re-elected president of New York Metropolitan Chapter at a meeting at Hotel Shelburne, March 19. Vice-president is Ralph Mollet; secretary, Joseph Previte; treasurer, Ed Everts. Members of the executive committee are: William Kauppert, Dan Chiswick, Herbert Engelmann, Dick Wheeler, Kenneth Fisher, Robert Bishop.

• • • •

Gordon Toms, of G. O. Toms Electric Co., Spokane, Wash. was elected president of Inland Empire Chapter at the group's first meeting since it was organized early this year. Serving as charter officers with Mr. Toms are Eldon T. Strom, vice-president, Troy, Idaho; and secretary-treasurer, Ed Kuder, K&N Electric Motors, Spokane. The meeting was held in Spokane on April 3 at the Davenport Hotel.

• • • •

Re-elected to serve terms as officers of Indiana Chapter were: President, Henry Hayden, Hayden Electric Co., Columbus, Ind.; vice-president Ivan Frakes Jr., Frakes Electric Co., Inc., Indianapolis; treasurer Fred McBroom, McBroom Electric Co., Indianapolis; and secretary, Burton Hannewald, Scherer Electric Co., Indianapolis.

• • • •

Al Lebowitz was elected president of Connecticut Chapter at a meeting in Hamden on March 5. Officers also include: vice-president, Michael Smaga; treasurer, Frank L. Johns; secretary, Edward A. Piteo; directors, Michael Phillips; William Palmer and Joseph Piela.

PHONE FOR MILES

without any current

Depending upon the wire used, Sound Powered Telephones will operate from short distances up to 30 miles or more without batteries or other power sources. Your voice supplies the energy to transmit speech in clear, distinct tones, free of all static. Indoor and outdoor models.

Write for catalog

HOSE-McCANN TELEPHONE CO., INC.

25th St. & 3rd Ave., Brooklyn 32, N.Y.

Reasons Why You Should*

*PURCHASE ONLY PAINE "SPRING WING" TOGGLE BOLTS

Paine "Spring Wing" toggle bolts, a Paine invention, are ideal for hanging or fastening anything to be mounted on a surface where you can't reach the other side. The many years of Paine toggle bolt development has produced an extremely wide range of styles, combinations and special designs. Sure-fire spring action, the u-channel wings and wide spread grip assure a secure, permanent installation.

Series #1000

*INSIST ON PAINE MACHINE SCREW ANCHORS

Paine expansion screw anchors offer more flexibility because you can use a variety of screw lengths, they are precision threaded with a natural easy opening to start the screw and they distribute equal pressure on all sides to assure tremendous holding power. You can set, pack, caulk, or tap this anchor to any desired depth, and it will make a neat, permanent installation.

Series #9000

the best craftsmen always take

PAINE'S

THE PAINE COMPANY, 10 Westgate Road, Addison, Illinois

KATOLIGHT STANDBY POWER

GASOLINE, GAS, DIESEL MODELS TO 500 KVA

We all agree it is good business to insure against unforeseen losses due to fire, wind or accident . . . but none is available to cover loss of time, inconvenience, discomfort, dangers that power failures bring. You're insured with Katolight Power Plants to keep your electrical equipment functioning whether for 3 minutes or 3 years.

KATOLIGHT PORTABLE POWER

AVAILABLE ON DOLLIES OR TRAILERS

Crews have "plug-in" power at their finger tips when and where they want it. "Quick, steady power for operating electric saws, grinders, drills, hammers, heaters, sanders, paint sprayers. No delays. . . . No nuisance power line hook-ups. 500 to 35,000 watts and up.

BIGGER OVERLOAD CAPACITY

WRITE FOR NEW BROCHURE!

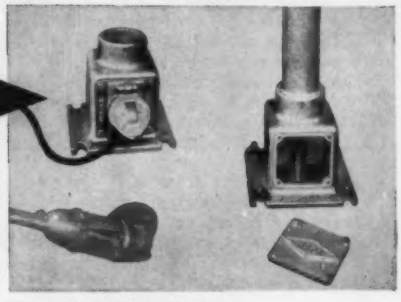
Katolight CORPORATION

Box 891-53 Mankato, Minnesota

For LOW COST Outdoor Lighting...Signs...Signals!

HOPE

METAL-PIPE POLE BASES



A Rugged Support for Threaded Pipe Uprights With Chamber for Splicing and Grounding.

EASY TO FABRICATE—Turn galvanized conduit or pressure pipe (single or coupled lengths) into threaded hub of base, and top-off with the fixture of your choice. Install over embedded anchor bolts and conduit stubs. Splice and ground through generous hand-hole—and the job is done.

Four base sizes permit simple fabrication of poles for a limitless variety of small and large fixture loads at varying elevations.

PROVED IN USE—Attractive installations for lighting parking areas, gas stations, railway platforms, sub-stations, industrial plants and shipping areas, sewage disposal works, pumping stations, schools, churches, hospitals, motels, marinas, resorts. Also as supports for signs and signals. Plain gasketed or 3 pole receptacle cover.

2" —H42200
2½"—H42250
3" —H42300
4" —H42400

Bulletin #25

HOPE ELECTRICAL PRODUCTS CO.

27 Long Avenue, Hillside, N. J. • ELizabeth 4-7837

UTILCO BODY OAKLAND

SERVICE AND MAINTENANCE BODIES

MODEL UB

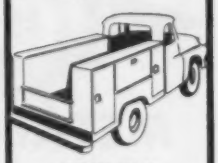
LOWEST COST · MODEL UB

CHECK THESE FEATURES THEN ...CHECK OUR LOW PRICES!

• Anti-Buckling, heavy duty corrugated or diamond plate floor with drainage outlets • Rigid front panel ribbed for stiffness • Removable dividers every 4" on tray in curb side horizontal compartment are held down with retainer to keep dividers from bouncing and causing parts to mix • 1" rolled lip provided on material shelf in left horizontal compartment • Heavy duty 12" tailgate opening to floor level • New flush pull-out type door handles with double slam action catches and master keyed cylinder locks • Handle protrudes when lock bolt is not fully engaged — warning when door not securely closed • All edges of parts hemmed for safety • Double panelled doors • Rod type hinges rolled into door hem • Doors hinged on special grease loaded bearings to prevent binding common with piano hinges • Full 48" Bed Width.

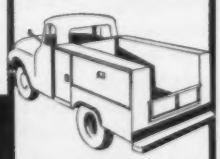
THE NEW MODEL UB SERVICE AND MAINTENANCE BODY is available to fit any ½ or ¾ ton chassis in a choice of three Compartment Layouts. The variety and flexibility of designs makes the UB UTILCO SERVICE BODY adaptable in a variety of fields including: Utilities, Plumbing, Electrical, Refrigeration, and governmental service. The Compartment interiors can be assembled to meet each customer's individual requirements. This is but one of a full and complete line of Service and Construction Bodies...write UTILITY BODY COMPANY or telephone your nearest distributor.

SERIES TC
TOOL COMPARTMENTS



MODEL UB-X

SERIES U-56
CROSS COMPARTMENTS



MODEL UB-T

UTILITY BODY CO.

1530 WOOD STREET • OAKLAND 7, CALIFORNIA • TWINOAKS 3-8980

DATES AHEAD

International Association of Electrical Inspectors—Baton Rouge, George Welman, North Louisiana-East Texas, Texas Gulf Coast Chapters, Five chapter joint meeting, Carlton Hotel, Tyler, Texas, May 15-16; **Northwestern section** Seatle Hotel, Seattle, Wash., August 24-26; **Canadian Section,** Montreal, Quebec, Canada, September 25-26; **Western Section,** Schroeder Hotel, Milwaukee, Wis., October 5-7; **Southern Section,** Heidelberg Hotel, Jackson, Miss., October 12-14; **Mississippi Chapter,** Heidelberg Hotel, Jackson, Miss., October 12-14.

Illuminating Engineering Society—Regional Conferences; **Pacific Northwest,** Buffalo Springs Hotel, Banff, Alta., (Canada), May 26-30; **Northeastern,** Curtis Hotel, Lenox, Mass., June 4-5; **Canadian,** Chateau Laurier, Ottawa, Ont., (Canada), June 11-12; **Great Lakes,** Statler Hotel, Buffalo, N. Y., June 22-23.

National Industrial Service Assn.—Queen Elizabeth Hotel, Montreal, Canada, May 17-21.

Building Research Institute—Building Illumination Conference, Statler-Hilton Hotel, Cleveland, Ohio, May 20-21.

National Association of Electrical Distributors—51st annual convention, Conrad Hilton Hotel, Chicago, Ill., May 24-29.

New York State Association of Electrical Contractors and Dealers—60th Annual convention, Whiteface Inn, Lake Placid, N. Y., July 7-10.

Western Electronic Show & Convention—Cow Palace, San Francisco, Calif., August 18-21.

Illuminating Engineering Society—National Technical Conference, Fairmont Hotel and Mark Hopkins, San Francisco, Calif., September 7-11.

Canadian Electrical Manufacturers Assn.—15th annual meeting, Sheraton-Brock Hotel, Niagara Falls, Ont., Canada, September 30, October 2.

11th Biennial Electrical Industrial Exposition—Sponsored by Essex Electrical League; Armory, Elizabeth, N. J., October 10-12.

National Electronics Conference — Sherman Hotel, Chicago, Ill., October 12-14.

Electrical Progress Show—Sponsored by Electrical Association of Philadelphia, Convention Hall, Philadelphia, Pa., October 13-15.

National Electrical Contractors Association—Annual convention and 5th National Electrical Exposition, Fontainbleau, Eden Rock, Deauville and Carillon Hotels, Miami Beach, Fla., November 9-12.

National Electrical Manufacturers Assn.—Annual meeting, Traymore Hotel, Atlantic City, N. J., November 9-13.

Industrial Electric Exposition—Sponsored by Electrical League of Western Pennsylvania, Penn-Sheraton Hotel, Pittsburgh, Pa., November 17-19.

MINERALLAC "PULL-IN" COMPOUND No. 100

LISTED and APPROVED by UNDERWRITERS LABORATORIES

For Rubber, Synthetic, Plastic or Lead-Covered Wires or Cables

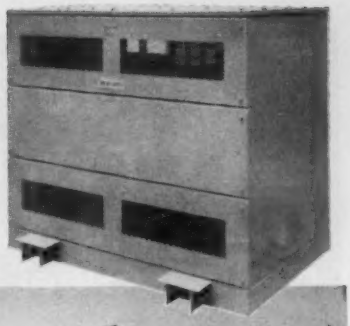
Approved by Underwriters Laboratories for lubricating wires and cables to facilitate pulling them into conduits. Not injurious to wire or wire covers. Free of objectionable odors. White in color. Will not drip or run. Convenient pint, quart, ½ gal., gal. and 5 gal. cans. Available through your electrical jobber.

MINERALLAC ELECTRIC COMPANY
25 North Peoria Street, Chicago 7, Illinois

MINERALLAC

another quiet
HEVI-DUTY
installation

225 KVA
480 — 208Y/120 Volts
Dry Type Transformer



PLACE: W. W. Samuell High School, Dallas, Texas
ARCHITECT: Office of Mark Lemmon, Dallas
ELECTRICAL CONTRACTOR: Gotham Electric Co., Dallas
ELECTRICAL CONSULTING ENGINEER: Zumwalt and Vinther, Dallas

HEVI-DUTY ELECTRIC COMPANY
HEAT PROCESSING FURNACES HEVI-DUTY ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS
MILWAUKEE 1, WISCONSIN

Write for Bulletins 100 and 200 today.

DRILL CONCRETE IN SECONDS

Instead of Hours with PENNDRILL (MASONRY DRILLING EQUIPMENT)

Holes can be drilled thru any type masonry material-concrete, marble, brick and tile; including reinforcing bars or other steel encountered.

Using diamond bits as the cutting agent, holes are drilled faster and at a lower cost than by any other method.

Penndrill equipment drills holes—1 to 14" in diameter up to 19" deep—vertically, horizontally or at any angle. Long life diamond bits in stock 3/16" to 14" in diameter.

Millions of holes have been drilled with Penndrill bits, cutting job costs up to 60%.

Write for illustrated literature

PENNSYLVANIA DRILLING CO.
MASONRY DRILL DIVISION
1201 Banksville Road, Pittsburgh 16, Pa.

IN ELECTRIC HEAT THERMOSTATS... WHITE-RODGERS IS THE LEADER!

Use them with confidence—they're specifically designed for Electric Heat by White-Rodgers—world's largest maker.

Sold under the brand names of more than fifty manufacturers of quality electric heating equipment.

Type 1A61
World's Largest Seller

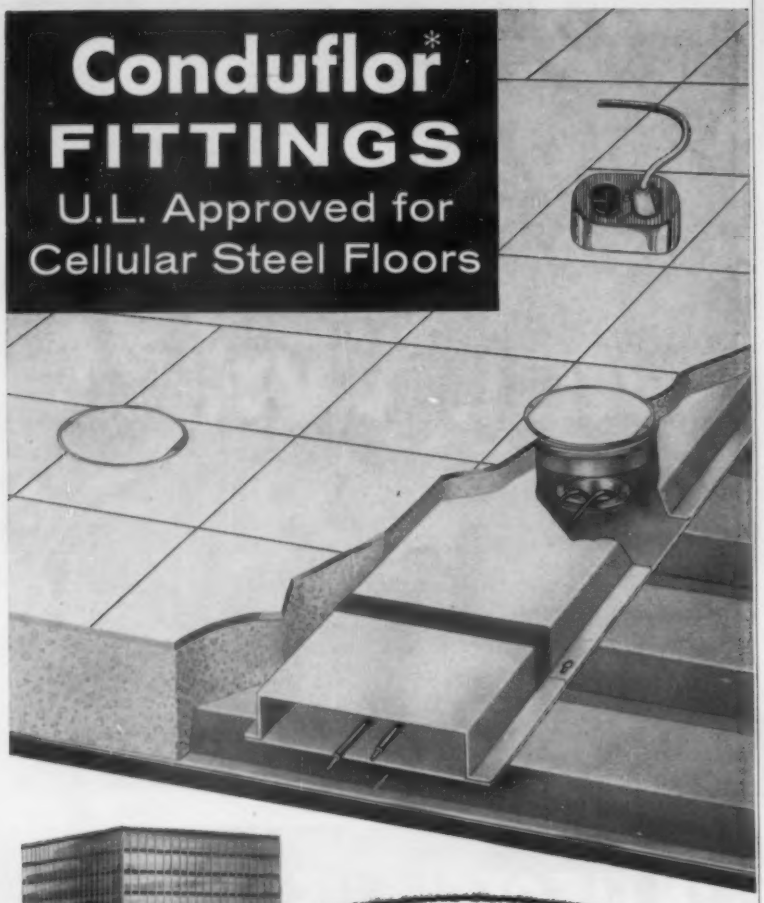
Type 1A65
Elegant New Companion

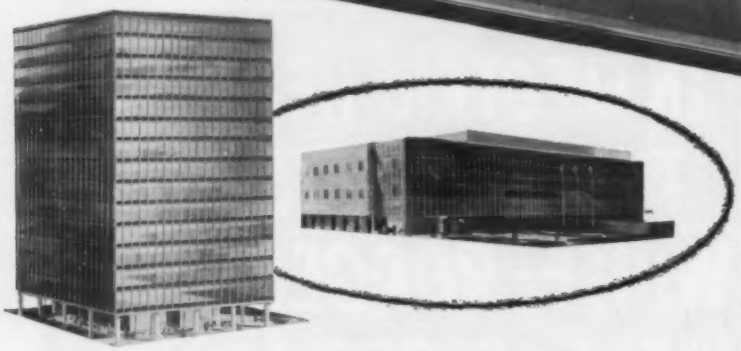
LIVE BETTER ELECTRICALLY

WHITE-RODGERS CO., ST. LOUIS 6, MISSOURI TORONTO 8, CANADA

Conduflor* FITTINGS

U.L. Approved for Cellular Steel Floors





Be sure you check...

CONDUFLOR'S exclusive design features when you bid your next job.

Approved Conduflor fittings are in use on all types of cellular steel floors.

Write or call for detailed data file.

*trade mark registered

CONDUFLOR CORPORATION

P.O. BOX 2748 CLEVELAND 11, OHIO

Among the Manufacturers

Headquarters Announcements

Curtis-Allbrite Lighting, Inc., has been formed through the merger of **All-Brite Fluorescent Fixtures, Inc.,** San Francisco, Calif., and **Curtis Lighting, Inc.,** Chicago, Ill. E. O. Anders is to be president and chairman of the board; Charles D. Buchanan will be general sales manager.

The American Metal Hose Div. of the American Brass Co. has been changed to **Anaconda Metal Hose Div.,** Waterbury, Conn.

General Electric Company's Conduit Products Dept. headquarters has been relocated from Bridgeport, Conn., to Niles, Ohio.

Ilg Electric Ventilating Co., Chicago, Ill., has purchased the General Blower Co., Morton Grove, Ill., which will be operated as the General Blower Div.

Westinghouse Electric Corp., Pittsburgh, Pa.—Mark W. Cresap, Jr., president and chief executive officer; Gwilym A. Price, chairman of the board.

United States Steel Corp., Cleveland, Ohio—Edward A. Murray, vice president—sales; Boyd P. Doty, Jr., general sales manager; M. E. Capouch, manager of distribution and availability; William H. Guterl, manager of marketing. All are with American Steel & Wire Div.

Acme Electric Corp. has moved its headquarters to its new plant in Hawthorne, Calif., with Ray McWaters as manager of engineering, Ken Burton as manager of sales.

Electric Auto-Lite Co., Toledo, Ohio—J. A. Cappi, assistant to vice president; R. C. Roderick, Toledo Division manager—both with Electrical Products Group.

Sylvania Electric Products Inc., New York—Arthur L. B. Richardson, vice president; John J. Davis, controller.

Westinghouse Electric Corp., Pittsburgh, Pa.—K. M. Patterson, manager of headquarters sales departments, Apparatus Division; T. Frank Saffold, manager of specialty transformer department.

White-Rodgers Co., St. Louis, Mo.—Robert N. Weber, manager of new Product Planning Division.

Cutler-Hammer Inc., Milwaukee, Wis.—Warren G. Cudlip, manager of quantity sales.

Markstone Mfg. Co., Chicago,

WE HAVE IN STOCK
HIGHLY TOOLED
PRECISION MADE
FLUORESCENT
fixture bodies
FOR THE TRADE

- COMMERCIAL
- INDUSTRIAL
- RECESSED
- ADJUSTABLE SPOTS

All fixtures tooled for minimum assembly, using minimum screws.

• WRITE FOR NEW COMPLETE LINE CATALOG TODAY

Oldest and most progressive manufacturer of fluorescent metal fixtures

CANNING-PEKARA, INC.
2144 North Wood Street, Chicago 14, Illinois
HUmboldt 9-4224

How You Benefit From
50 Years of Service
To The Electrical Industry

RELIANCE AUTOMATIC LIGHTING CO. 50th Anniversary 1909-1959

Exclusive specialization in the manufacture of precision-made time switches since 1909 qualifies Reliance to be more than just a little proud of their continuing performance record. Nothing is spared to produce the long-lasting precision devices which are giving year 'round dependable service. Many Reliance switches have been in continuous use for 20, 25 or more years.

50 amp. "BADGER"

The heavy duty 50 amp. "BADGER" is the pride of the Reliance line. Copper-to-copper contacts with pressure type terminals. Extra heavy brass gears run with steel pinions. Heavy-duty synchronous motor assures longer working life. Vernier time set. Indoor or outdoor cabinets.

Optional features include omitting device, extra trippers, one hour dial. Other stock models include the versatile 30 amp. Model W, available in seven standard types . . . and the budget-priced 20 amp. Model 400, which has all the convenience features of the higher priced models.

Write for FREE Catalog!

RELIANCE AUTOMATIC LIGHTING CO.
1927 Mead Street • Racine, Wisconsin

ALUMINUM
RIGID Conduit
PIPE FITTINGS

CONDUIT NIPPLE MFG. CO.
1455 SPRING GARDEN AVE. PITTSBURGH 12, PA.

Selection and Specification Data

Write for Bulletin 158

THE Adalet MANUFACTURING COMPANY
14300 LORAIN AVENUE • CLEVELAND 11 OHIO

MEG® TYPE

OF

MEGGER

(Reg. U. S. Patent Office)

Rectifier-Operated

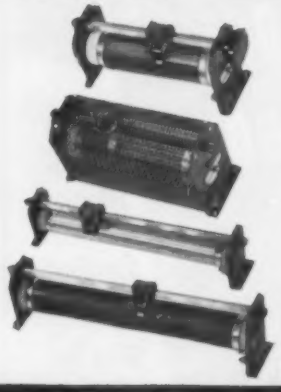
INSULATION TESTERS

For repetitive insulation resistance tests on a production basis . . . and for time-resistance tests . . . nothing equals the Meg Type Rectifier-Operated Insulation Tester for convenience and reliability. The plug-in rectifier source of power permits the instrument to be used without hand cranking. A constant-voltage feature reduces pointer fluctuations which may occur when testing equipment having appreciable capacitance, such as larger generators and long cables. Standard units are available for 500 or 1000 volts d-c test potential and for ranges up to 2000 megohms.

Other Megger Insulation Testers include hand-crank models and Dual-Operated sets. The latter are versatile instruments with rectifier for repetitive or time-testing that can be disconnected for hand-crank operation in the field.

Write for BULLETIN 21-46-ECM

JAGABI® LUBRITACT® RHEOSTATS



Recently announced design refinements make these rheostats better than ever. A wide range of improved models features interchangeable components and sturdier construction. Three basic types include:

1) Screw-drive for precise knob adjustment; 2) slider type for quick control; and 3) new cage type for maximum operator safety. Whatever your needs, in shop, testing department or lab—Jagabi Lubritact Rheostats assure you the most up-to-date advantages.

Write for BULLETIN 41-ECM

JAMES G. BIDDLE CO.

• ELECTRICAL TESTING INSTRUMENTS
• SPEED MEASURING INSTRUMENTS
• LABORATORY & SCIENTIFIC EQUIPMENT

1316 ARCH STREET
PHILADELPHIA 7, PA.

Ill.—Joseph A. Tills, vice president in charge of sales.

Pittsburgh Standard Conduit Co., Pittsburgh, Pa.—A. J. Zoth, member of the board.

U. S. Industries, Inc., New York—L. J. Lieberthal, president, Conduit Fittings Div.

Porcelain Products Co., Carey, Ohio—C. Rae Guthridge, sales manager; Ralph Shontz, manager of custom products sales.

Markel Electric Products, Inc., Buffalo, N. Y.—David Markel, treasurer and executive vice president; Morris L. Markel, vice president in charge of engineering; Lester M. Markel, vice president in charge of purchasing; Richard C. Piper, vice president in charge of sales; Dennis R. Ogden, vice president in charge of production.

Minneapolis-Honeywell Regulator Co., Minneapolis, Wis.—Fred Maytag II, director.

Kennecott Copper Corp., New York—J. Peter Grace, Clifton W. Phalen and R. Stuart Keefer, members of the board.

Precision Transformer Corp., Chicago, Ill.—B. C. Biega, assistant sales manager.

Engelhard Industries, Inc., New York—Charles de Rohan, production manager, Hanovia Lamp Div.

Litecraft Mfg. Corp., Passaic, N. J.—Sidney Sheldon, vice president, contract sales.

Columbia Cable & Electric Corp., Brooklyn, N. Y.—Michael J. St. John, general sales manager; David I. Feldman, plant manager.

Regional Appointments

MIDDLE ATLANTIC

R. E. Uptegraff Co.: E. B. McKinney, representative in western Pennsylvania.

Thomas Industries Inc.: Warren Brennan, Moe Light sales representative in state of New York.

Hoffman Engineering Corp.: John C. Fox & Son, agent in New York State; Love-Haile Co., agent in western Pennsylvania and West Virginia.

DuKane Corp.: Herbert M. Jaffe, manager of eastern region, including New England, east central states, and Atlantic seaboard.

Allis-Chalmers Industries Group: Robert I. Carlson, representative to Pittsburgh district; George E. Piper, representative to Philadelphia district.

Westinghouse Electric Corp.: Francis X. Winn and Harry A. Cheney, regional managers of northeastern and mid-Atlantic regions, respectively, for Total Electric Home program.

HOME WIRING MANUAL

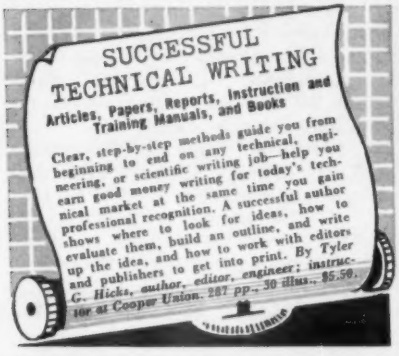
Enables you to plan the "small distribution system" needed in the typical modern home electrical installation from beginning to end! Methods for determining loads, service entrance feeder size, number and size of branch circuits, number and type of outlets, etc.—a new three-degree approach for simplifying the whole job of planning—quick reference tables and other working helps—sample contract specifications—and much more are given in this handy manual. **By A. C. Bredahl, Westinghouse Electric Corp. 221 pp., 101 illus., $4.95.**

ELECTRICAL CONSTRUCTION COST MANUAL

Shows you how to get **accurate cost estimates** of electrical construction work—fully explains what you should do to bring all the vital cost factors of a job together in an integrated cost system. Step by step it establishes methods for installing work in various types of construction, develops standard assemblies for these conditions, sets up material and labor unit costs for each assembly, and gives a detailed estimating procedure for applying the unit costs. **By R. E. Johnson, President, Sturgeon Electric Co. 427 pp., 226 illus., $10.00.**

STANDARD HANDBOOK for ELECTRICAL ENGINEERS

Thousands of facts and figures, systems and measurements, methods and materials from all fields of electrical engineering. Covers everything from electric and magnetic circuits, regulators, and prime movers—to illumination, power system electrical equipment, and electronics. New information on transistor-nuclear power dielectrics for capacitors, synthetic resins and plastics, automation, telemetering, etc. **Editor-in-Chief: A. Knowlton, Consulting Ed., *Electrical World*. 9th Edition, 2230 pp., 1725 illus., $21.00.**


SUCCESSFUL
TECHNICAL WRITING
Articles, Papers, Reports, Instruction and Training Manuals, and Books
Clear, step-by-step methods guide you from beginning to end on any technical, engineering, or scientific writing job—help you earn good money writing for today's technical market at the same time you gain professional recognition. A successful author shows where to look for ideas, how to evaluate them, build an outline, and write up the idea, and how to work with editors and publishers to get into print. By Tyler G. Hicks, author, editor, engineer; instructor at Cooper Union. 287 pp., 30 illus., $5.50.

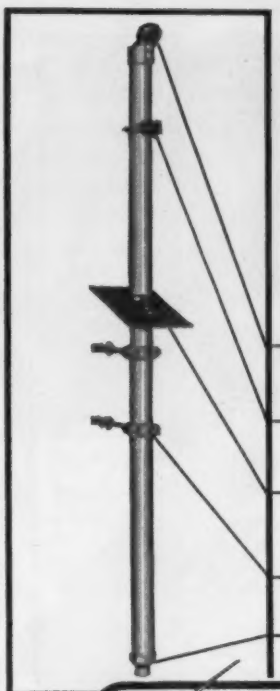
EXAMINE THESE BOOKS 10 DAYS FREE

McGRAW-HILL BOOK CO., Inc., Dept. EC-5
327 W. 41st St., New York 36, N. Y.

Send me book(s) checked below for 10 days' examination on approval. In 10 days I will remit for book(s) I keep, plus few cents for delivery costs, and return unwanted book(s) postpaid. We pay delivery costs if you remit with this coupon—same return privilege.)

- ☐ Bredahl—Home Wiring Manual, $4.95
- ☐ Johnson—Elec. Const. Cost Manual, $10.00
- ☐ Knowlton—Stand. Hdbk for Elec. Engrs., $21.00
- ☐ Hicks—Successful Tech. Writing, $5.50

(PRINT)
Name .....
Address .....
City ..... Zone.... State.....
Company .....
Position .....
For price and terms outside U. S. write McGraw-Hill Int'l., N.Y.C. EC-5



INSTALLED FAST BUILT TO LAST

Blackhawk Service Entrance Mast Kits better from top to bottom

5 GOOD REASONS *why a Blackhawk kit means a faster, better installation from cable entrance to meter. May be purchased as a complete kit or as separate fittings.*

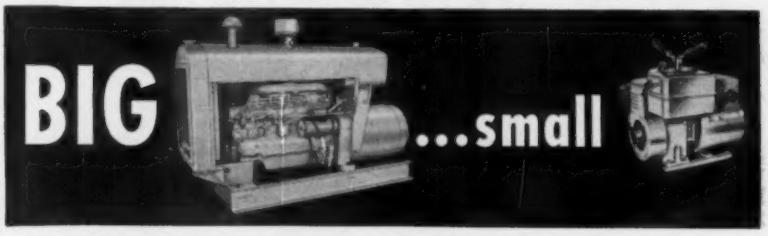
1. **Slip-fitter service entrance head** — Just slip it on over conduit and tighten two set screws. That's all. Made of corrosion-resistant aluminum. Available in a full range of sizes. (Patent applied for.)
2. **Insulators** — Reinforced, durable, well-rounded porcelain secured to metal pipe mounting clamp, galvanized.
3. **Flexible Synroflashing** — Made of flexible neoprene to absorb vibration. Mast can't work loose, damage shingles, or cause leaks. Won't rot, peel or crack in any weather. Available for 1¼, 1½, 2 and 2½" pipe.
4. **Mounting brackets** — Exposed parts corrosion-resistant aluminum alloy. Shoulder eye fits flat. Lock set screw gives additional grip. Meets installation requirements.
5. **Offset reducer** — Corrosion-resistant aluminum alloy. Fits 1¼" and 1½" hubs to a 2" or 2½" pipe riser.

The better-made parts in a Blackhawk kit let you do a fast and sound job on every service entrance mast installation. Saves you time, builds your reputation for quality and service.

Specify B-I when you buy!

Blackhawk Industries

DUBUQUE, IOWA *where the new ideas come from*



...and all sizes in between!

UNIVERSAL ELECTRIC PLANTS

give you a model for every need

When it comes to electric plants, come to Universal for exactly what you need. It's the most selective line—all models featuring matched unit design with generator, engine and controls precisely matched to each other for highest rated performance.

All Sizes, Types and Controls—for every application, emergency, intermittent or constant service. Gasoline or diesel models from 250 watts to 35 k.w.—air- and radiator-cooled, single- and multi-cylinder. All voltages, phases. Widest control selection—from manual to fully automatic.

PRICED TO GET YOU MORE SALES, MAKE YOU MORE MONEY!

New, comprehensive fold-out "electric plant finder" gives you full details, specifications and information on the full Universal line. Use this coupon.

Universal of Oshkosh
MARINE ENGINES • ELECTRIC PLANTS

Universal Motor Company,
438 Universal Drive, Oshkosh, Wis.
Send me your all-new, complete-line bulletin—also prices.

Name.....
Firm.....
Address.....
City.....Zone.....State.....

COUCH AUTOMATIC NURSES CALL SYSTEM

DESIGNED FOR SUPERIOR PERFORMANCE

Couch U/L approved Nurses Call Systems provide:

Visual signaling with audio communication
Fully automatic master stations
Emergency calls selected ahead of existing calls

Nylon pull cord stations provide these advantages:

Automatic or manual reset
Low maintenance cost and ease of sterilization
Can be used in oxygen tent
Break away feature to eliminate station damage

Optional system features:

Area paging
Communication between remote points
Two systems may be combined for a central operation

Your step-by-step guide to Nurses Call Systems design, available on request, is Couch Bulletin 137

Couch **S.H.Couch** CO., INC.

3 Arlington Street North Quincy, Mass.

SOUTH ATLANTIC

Wolverine Tube, Div. of Calumet & Hecla, Inc.: Robert W. McKenzie, sales representative in Birmingham, Ala., district.

Westinghouse Electric Corp.: John G. Adams, manager of southeastern region for Total Electric Home program.

Anderson Electric Corp.: Gaddis G. Hall, sales representative in South Georgia and Florida.

EAST CENTRAL

Arro Expansion Bolt Co.: Edgar J. Haas, Jr. and Associates, representative for states of Arkansas, Louisiana and Mississippi.

Westinghouse Electric Corp.: Charles R. Beatty, manager of southwestern region for Total Electric Home program.

Diamond Expansion Bolt Sales Co., Inc.: J. J. Miner Co., agent for state of Michigan and Toledo, Ohio.

Cutler-Hammer Inc.: F. W. Walter, manager of new sales office in Toledo, Ohio.

Clark Controller Co.: Paul R. Gravenstreter, district engineer for new Detroit district office.

Robertshaw-Fulton Controls Co.: Walter H. Morris, midwest district sales manager for electrical controls.

WEST CENTRAL

Minnesota Mining & Mfg. Co.: Richard R. Vehr, Dallas branch sales manager.

Day-Brite Lighting, Inc.: Samuel W. Charlesworth, central regional sales manager.

Sylvania Lighting Products: C. H. Connely, Denver area district sales manager.

WEST

Wincharger Corp.: Premmco, Inc., representative in California and Nevada; C. F. L. Co., Inc., representative in Colorado, Utah, Wyoming and Idaho.

Westinghouse Electric Corp.: J. G. McKinley and Herman L. Wiler, managers of Pacific Coast and Northwestern regions, respectively, for Total Electric Home program.

Quadrangle Mfg. Co.: John Allen Ware & Associates, representative in Arizona.

DuKane Corp.: L. C. Klewin, western region manager.

Sylvania Electric Products: Robert W. Erskine, sales supervisor in Portland, Ore.

Minnesota Mining & Mfg. Co.: Robert W. Rayburn, San Francisco-Seattle area sales manager.

UTILITY
DRY TYPE TRANSFORMERS

SINGLE AND 3 PHASE
INSULATING INDOOR
Sizes ½ to 1000 KVA
Voltages up to 15,000 V.

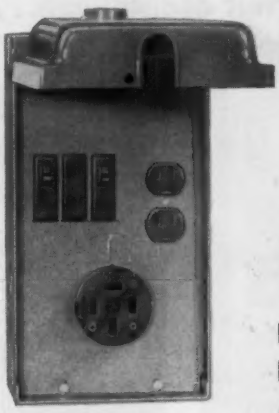
GIVE YOU
QUALITY and PRICE!

Highest quality performance . . . years of dependable service . . . priced to save you money . . . those are the advantages of UTILITY DRY TYPE TRANSFORMERS. They're fully guaranteed, too, so investigate the advantage of installing Utility Transformers now, you'll be glad you did.

Write today for new price and discount sheets. Several attractive dealerships and agents territories still open.

Utility TRANSFORMER AND EQUIPMENT CO.
702 Lynn Ave BARABOO, WISC.

Direct your inquiries to our National Stocking Distributor
CHICAGO *Electric Co.*
1322-24 W. Cermak Rd. • Chicago 8, Ill.



Weatherproof All-Purpose
POWER OUTLETS
FOR OUTDOOR CONSTRUCTION, INDUSTRY, FARMS, RANCHES AND MOBILE HOME PARKS!

MODEL P-55-C

MODEL P-55-C, as illustrated, has a 60 amp, 250 volt, 4 wire power receptacle, protected with a two pole 50 amp circuit breaker. Also has a grounded type duplex receptacle protected with a one pole 20 amp circuit breaker. Top hub and bottom KO's facilitate overhead or underground connections. Completely weatherproof. Cover closes completely when in use and can be padlocked. Over 70 other standard models to choose from in fused or circuit breaker types with 15 to 60 amp, 3 and 4 wire receptacles.

Representatives: SOME EXCLUSIVE TERRITORIES ARE STILL OPEN!

SEE YOUR LOCAL ELECTRICAL DISTRIBUTOR OR WRITE

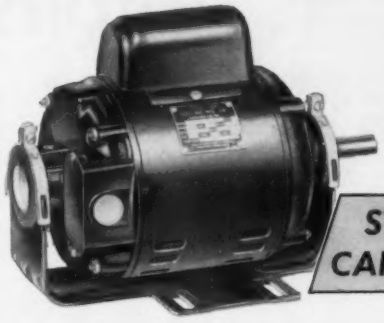
Midwest ELECTRIC PRODUCTS, INC.
DEPT EC, MANKATO, MINNESOTA

WHERE TO BUY
Equipment, Materials, Supplies and Services for Electrical Construction—Maintenance—Repairs

HAMMER + DRILL

The WODACK® "DO-ALL"®
is a powerful, hard hitting electric hammer. Presto Change! In one minute it's an electric drill with ⅜" Jacobs chuck.
Imagine how useful this two-way tool can be in maintenance work. A public service company has 121 of them. A chemical company has 128. Drills concrete to 1¼" dia. and to 24" depth. 20 types of hammer tools. Sold factory-to-user. Ask for BULLETIN 562-EC. WODACK ELECTRIC TOOL CORP., 4627 W. Huron St., Chicago 44, Ill.
Our 43d year making Wodack Electric Tools

IDENTIFICATION NAME PLATES
Machine engraved on black bakelite with white lettering—any titles—for controls, panels, etc. Quick mail service any distance. Send for free sample and prices.
G. F. BUNNELL CO.
645 Cypress Road, Vero Beach, Florida



Dayton

STANDARD-DUTY CAPACITOR MOTORS

Power Packed—Tops in Dependability

DAYTON MAKES:
Split-Phase Motors
Capacitor Motors
Three-Phase Motors
Shaded Pole Motors
Repulsion-Induction
Gear Head Motors
AC-DC Motors
Generators, 115 & 230V
Fans & Fan Parts

BUILT TO OUT-PERFORM other standard-duty capacitor motors—yet priced to save you up to 20%. Daytons are doing an outstanding power job on machinery, pumps, blowers, conveyors, etc.—everywhere.

375% STARTING TORQUE. 1/4 to 1 HP sizes 1725 RPM, 115/230V, 60 Cy. 50°C. rise, continuous duty. All-position sleeve and ball-bearings. Rubber and rigid mounted. Nema 56 frames.

GRAINGER'S WHOLESALE CATALOG features Dayton, Westinghouse, General Electric, Emerson and Wagner Motors. All stocked at your nearby Grainger Warehouse.

WRITE FOR NET-PRICE WHOLESALE MOTOR CATALOG
Dept. 76. 118 S. Oakley Blvd. Chicago 12

63 COAST-TO-COAST WAREHOUSES
W.W. GRAINGER INC
MOTORS - FANS - PUMPS
GENERATORS - BLOWERS

the best switch for all on-off circuit applications...

SANGAMO
HEAVY-DUTY TIME SWITCHES

automatically control switching schedules in exact accordance with your specific needs

Put Sangamo Heavy-Duty Time Switches, equipped with astronomic dials, to work in your lighting installations. Years of dependable, accurate and trouble-free service prove these the best switches for all on-off circuit applications.

Sangamo's astronomic dial controls switching schedules automatically in exact accordance with sunset and sunrise, or off before midnight, if you wish. It compensates progressively day by day for the change in the length of daylight and is available for all latitudes.

Only Sangamo Heavy-Duty Time Switches also offer the electrically-wound automatic carryover which keeps switch running for as long as 10 hours during power outages. No resetting or rewinding is necessary.

Your Electrical Wholesaler can furnish you with all types of dependable, accurate Sangamo Time Switches. See him, today, for full information.

SANGAMO ELECTRIC COMPANY
SPRINGFIELD, ILLINOIS

ST58-3

Now is the TIME to SWITCH to SANGAMO

Advertising

A

Abolite Lighting Div., The Jones Metal Products Co.... 14
• Accurate Mfg. Co..... 4
Acme Steel Co..... 20
• Adalet Mfg. Co., The..... 369
Adam Electric Co., Frank..... 194
• Advance Transformer Co..... 271
Allen-Bradley Co. 231, 232
Allis-Chalmers Mfg. Co....13, 15, 94
• All-Steel Equipment, Inc..... 63
Aluminum Co. of America..18, 19
• American Brass Co., The American Metal Hose Branch.... 68
• American Louver Co..... 273
American Pamcor, Inc..... 224
• American Steel & Wire Div. of U.S. Steel Corp.....276, 277
American Telephone & Telegraph Co. 11
Amprobe a Div. of Pyramid Inst. Corp. 21
Amprobe Jr., A Div. of Pyramid Inst. Corp. 310
Anaconda Wire & Cable Co. 108, 109
Appleton Electric Co..... 2
• Arro Expansion Bolt Co..... 362
• Arrolet Corp. 355
Associated Research Inc..... 353
Auth Electric Co., Inc..... 334
Automatic Switch Co.....54, 55

B

Baker-Roos, Inc. 320
Beaver Pipe Tools, Inc..... 304
• Bell Electric Co..... 325
Bell Telephone System..... 11
• Berko Electric Mfg. Corp.... 361
Biddle Co., James G..... 370
Black & Decker Mfg. Co..321, 363
Blackhawk Industries..... 371
• Blackhawk Mfg. Co..... 69
• Briegel Method Tool Co..... 228
Brook Motor Corp..... 359
Bryant Electric Co., The...32, 33
• Buchanan Electrical Products Corp. 319, 361
BullDog Electric Products Co. 85, 87, 89, 91, 93
Bunnell Co., G. F..... 373
Burndy Corp. 186
Bussmann Mfg. Co.....64, 65

C

• Canning-Pekara, Inc. 369
Carol Cable Co., Div. of the Crescent Co., Inc..... 246
Century Electric Co.....50, 51
Certified Ballast Mfgrs..... 234
Champion Lamp Works..... 345
Chase-Shawmut Co., The..... 324
Chester Cable Corp..... 289
Cincinnati Time Recorder Co.. 358

In This Issue

Circle Wire & Cable a Subsidiary of Cerro de Pasco Corp. 197
Clark Controller Co., The..... 81
• Collyer Insulated Wire Co..... 335
Conduflor Corp. 368
Conduit Fittings Div. of U.S. Industries Inc. 345
Conduit Nipple Mfg. Co..... 369
Continental Wire Corp..... 312
• Cope Div., T. J., Rome Cable Co. 286, 287
• Couch Co., Inc., S. H..... 372
• Crescent Insulated Wire & Cable Co. 190
• Crouse Hinds Co....Fourth Cover, 177, 178, 179, 180
Curtis Lighting, Inc.....58, 59
• Cutler-Hammer, Inc....28, 29, 182

D

Day-Brite Ltg., Inc..... 188
Diamond Expansion Bolt Co., Inc. 360
Diamond Wire & Cable Co.... 79
Dodge Corp., F. W..... 72
• Dossert Mfg. Corp..... 80
duPont deNemours & Co., Inc. E. I. 92
Dutch Brand Div., Johns-Manville 258

E

Eagle Electric Mfg. Co., Inc.. 333
Edwards Co., Inc.....56, 57
Efficiency Electric & Mfg. Co.. 361
Electric Distribution Products, Inc. 322, 323
• Electri-Flex Co. 357
• Electro Lighting Corp..... 376
Electromode Div. of Commercial Controls Corp..... 341
Ettco Wire & Cable Corp..... 25

F

Feedrail Corp. 356
• Fullman Mfg. Co..... 347
Furnas Electric Co..... 330

G

• Garcy Lighting Div. of Garden City Plating Mfg. Co..... 349
• Gateway Engineering Co..... 208
Gedney Electric Co..... 291
• General Cable Corp.....70, 71
• General Electric Co.
Apparatus Sales Div..35, 36, 37, 38, 39, 42, 43, 44, 45, 46, 47, 48, 49, 253
Construction Material Div. 336, 337
Distribution Assemblies Dept. 104, 105
Wiring Device Dept...293, 295, 297, 299

continued on page 376

KEES
SOCKET METER COVER

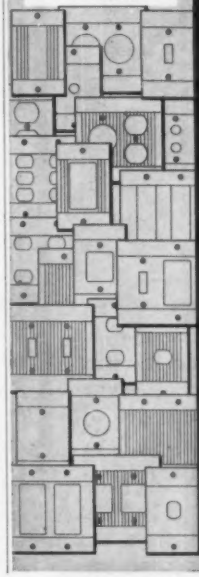
Fits All Standard "S" Type Meters

Made from 16 gauge zinc-coated, rust resistant steel and finished in gray baked-on enamel, the KEES Socket Meter Cover is designed to prevent breakage of glass on socket meters and to insure long service in any climate. Outside diam.—8" and depth—5⅛" and over. Metal cover is also reported to minimize damage from excessive current surge due to electrical storms.

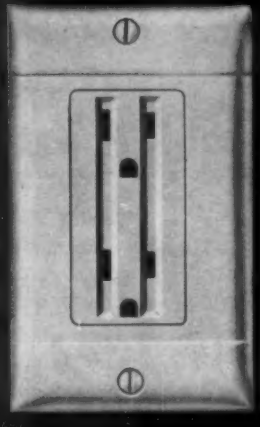
Write P. O. Box 739 for Free Electrical Catalogue.

F. D. KEES MFG. CO.
BEATRICE NEBRASKA
Since 1874

Sierra
WALL PLATES
Choose from world's largest selection, in plastic or metal all handsomely styled.



Sierra
FINE WALL PLATES & WIRING DEVICES



SIERRA ELECTRIC CORPORATION
15100 South Figueroa, P.O. Box 85
Gardena, California

MERCURY SWITCHES
Specification Grade and UL approved, each is individually tested and "T" rated. Can be wired either top or back. Silent, too-just try them!

SIERRAPLEX RECEPTACLES
A new line and complete line of Specification Grade outlets. Distinctively designed with "the look of tomorrow," a complement to any decor.

SIERRA RECEPTACLES
Conventionally styled and crafted to Specification Grade. Like Sierraplex, these premium outlets meet all Federal, NEMA, ASA, NEC, and REA standards.

FREE! 112-page Lighting Catalog

Specifying lighting demands complete, up-to-date information. The Electro Lighting Corporation general catalog is packed with photometric data, dimensional information . . . all the facts needed to write intelligent lighting specifications. It is kept current with the addition of pages on every major product change and innovation. For your up-to-the-minute copy, just attach this ad to your letterhead, and address to:

Department R12.

Electro Lighting Corporation

1535 South Paulina St. • Chicago 8, Ill.

---

bends rigid or thinwall conduit with ONE frame!

TAL BENDER Set No. 2C-EMT combines everything needed for better on-the-job bends

You get everything needed for quick, smooth bending of 1" to 2" rigid and thinwall conduit up to 90° using the same frame. Set No. 2C-EMT includes basic 2" TAL BENDER, plus all shoes, bars, clamps and attachments, packed in sturdy wooden chest. High speed TAL BENDER MP-27 Motor Pump may be used for faster bending. Write for Catalog No. 35 which details the *complete* TAL BENDER line in sizes from ⅜" to 8", or see your electrical wholesaler for full information.

Hein-Werner CORPORATION
WAUKESHA, WISCONSIN

continued from page 375

General Switch Co. 218
• Good Mfg. Co., Inc. 359
Grainger Inc., W.W. 373
• Graybar Electric Co., Inc. 112
• Greenlee Tool Co. 338, 339
• Guth Co., Edwin F., The Second Cover, 326

H

Hatfield Wire & Cable Div. of Continental Copper & Steel Industries, Inc. 239
Heinemann Electric Co. 61
Hein-Werner Corp. 376
• Helwig Co. 361
Henderson-Hazel Corp. 325
Hevi-Duty Electric Co. 367
Hoffman Eng. Corp. 346
• Holophane Co., Inc. 52, 53
Holub Industries Inc. 331
• Hope Elect'l. Products Co. 365
• Hose-McCann Telephone Co., Inc. 365
• Hubbell Inc., Harvey 110, 199
• Husky Products, Inc. 332

I

• Ideal Industries, Inc. 82, 340
• Ideal-Simplet Fittings, Inc. 327
Ilg Electric Ventilating Co. 275
International Metal Hose Co., The 349
• I-T-E Circuit Breaker Co. ..73, 74, 75, 76

J

Jenkins Brothers 262
Jet Line Gun Co. 352
• Johns-Manville 292
Jones Metal Products Co., The. 14

K

Kalamazoo Tank & Silo Co. ... 363
• Katolight Corp. 365
• Kees Mfg. Co., F.D. 375
• Keystone Mfg. Co. 348
• Killark Electric Mfg. Co. ..106, 107
Klein & Sons, Mathias 333
Knopp Inc. 343

L

Lake Shore Electric Corp., The. 313
• Leviton Mfg. Co. 316
• Lidseen of North Carolina, Inc. 343
Lighting Products Inc. 98
Lightolier, Inc. 294
Line Material Industries. . .213, 214
• Lint, Clyde W. 363
Litecontrol Corp. 78

M

• M & W Electric Mfg. Co., Inc., The 377
• Marcus Transformer Co., Inc. . 363
Mark & Co., Clayton 318
McGill Mfg. Co., Inc. 12
• McGraw-Hill Book Co. 371
• Meyer Machine, Inc. 339
• Midwest Electric Products, Inc. 373
• Minerallac Electric Co. 367
Minnesota Mining & Mfg. Co. . 83

Mitchell Lighting Co., Div. of Compco Co. 341
• Multi Electric Mfg. Inc..... 355

N

National Price Service..... 325
National Supply Co., Tubular Products Div. 202
NuTone Inc. 9, 10

O

Okonite Co., The.....30, 204
• Onan & Sons, Inc., D.W..... 327
Orangeburg Mfg. Co..... 290
• O.Z. Electrical Mfg. Co., Inc.. 256

P

Paine Co., The.....365, 378
Paramount Industries, Inc..... 255
Paranite Wire & Cable Div. Essex Wire Corp..... 267
Pass & Seymour, Inc..... 27
Pennsylvania Drilling Co..... 367
Penn-Union Electric Corp...6, 7
Permacel 216
• Phelps Dodge Copper Products Corp. 222
Pittsburgh Standard Conduit Co. 240
• PLM Products, Inc..... 342
• Plymouth Rubber Co., Inc..... 245
Porcelain Products, Inc..... 328
• Precision Transformer Corp... 298
Pyle-National Co., The..... 226

R

Ramset Fastening Inc..... 344
Rawlplug Co., Inc., The..... 309
• Reliance Automatic Ltg., Co... 369
Remcon, A Div. of the Pyramid Instrument Corp. 96
Republic Steel Corp..... 77
Revere Electric Mfg. Co..... 24
Reynolds Metals Co.....100, 101
Ridge Tool Co., The.....314, 315
RLM Standards Institute, Inc.. 221
• Rodale Mfg. Co., Inc..... 274
Rohm & Haas Co..... 264
• Rome Cable Corp.....60, 62
Royal Electric Corp.....331, 354

S

• S & C Electric Co..... 351
Sangamo Electric Co..... 374
Sherman Mfg. Co., H. B..... 329
• Sierra Electric Corp..... 375
• Simplex Wire & Cable Co..284, 285
Smithcraft Lighting 41
• Sola Electric Co., Div. of Basic Products Corp. 192
• Sorgel Electric Co..... 300
Southwestern Plastic Pipe Co.. 350
Sprague Electric Co..... 353
Square D Co...Third Cover, 1, 31, 102, 103
Stampings, Inc. 303
Standard Transformer Co..... 364
• Steel City Electric Co..... 242
• Steelduct Co., The..... 17
Steel & Tubes Division..... 77
Stephens Mfg. Inc., M..... 359

continued on page 378

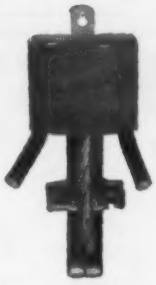
Wheelock SIGNALS INC

The "know-how" name in fire alarm systems

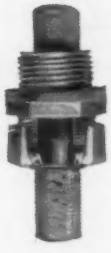
Wheelock Signals' know-how in designing and producing complete fire alarm systems has been expanding and maturing for 40 years.
Technical competence, refined and re-enforced by extensive experience, is made available to aid you in providing adequate protection to structures of any size, now on the drawing board or in use for any period of time — office buildings, school buildings, industrial facilities, hospitals and sanitoriums.

Write for descriptive bulletin FA-3 and the address of your local sales representative.

Wheelock SIGNALS INC
LONG BRANCH, N. J.



Now! M & W Electric 100-150-200 Ampere Service Entrance Fittings



Meet the ever-growing demand for larger service entrance requirements — use entrance cable with M&W ENTRANCE FITTINGS. These include: Entrance Heads, Straps, Watertight Connectors, Non-watertight Connectors and Sill Plates. Available are a complete line of fittings for cable sizes 3 No. 3 to 3 No. 4/0 using 1″, 1¼″, 1½″ or 2″ hubs.

Send for New No. 59 illustrated Price Sheet with complete details.

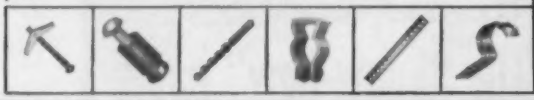
M&W Electrical Fittings
The M. & W. ELECTRIC MFG. CO., Inc.
EAST PALESTINE, OHIO

SPECIFY RELIABLE PAINE PIPE STRAPS

Paine offers a complete line of pipe and EMT heavy-duty straps. Each size is clearly stamped right on the strap, and they are designed for a wide variety of applications. All sharp corners or burred edges have been eliminated and Paine straps are beaded for extra strength. They are available in one or two hole styles and can be furnished with copper plating.

the best craftsmen always take

THE PAINE COMPANY, 10 Westgate Road, Addison, Illinois



PAINE'S

SEARCHLIGHT SECTION

EMPLOYMENT: BUSINESS: Classified Advertising **"OPPORTUNITIES"** EQUIPMENT USED OR RESALE

NEEDED NOW

ELECTRONIC ENGINEERS

In Alaska

$5430 to $8810 per annum plus 25% cost-of-living allowance. Enjoy a career in the Federal Civil Service with paid annual and sick leave, retirement benefits, paid transportation to Alaska and return for leave purposes. Positions in Federal career service. Contact:

Federal Aviation Agency

P. O. Box 440 **Anchorage, Alaska**

TRANSFORMERS

BOUGHT — SOLD — RENTED

REWOUND — RE-DESIGNED

MANUFACTURED

Ask For Our Price Schedule And Stock List

THE ELECTRIC SERVICE CO., 5322 Hetzel St., Cincinnati 27, Ohio

"America's Exclusive Independent Transformer Service Shop"

Announcing

ELECTRICAL CABLE TESTING

D.C. HI-POT CABLE TESTING SERVICE

Mobile Equipment Capable of 120KV D. C. Maximum Test Voltage

Now Available To Electrical Contractors, Industrial Plants, and Other High Voltage Cable Users at Reasonable Rates.

Call or Write

UNIVERSAL TESTING CORPORATION

2929 North Paulina Street, Chicago 13, Illinois

EAstgate 7-4644

WIRE and CABLE WHEN YOU NEED IT

From Chicago you can get immediate delivery on all types of Electric Cable. Order today. We ship same day.

Send for our latest stock sheet

UNIVERSAL WIRE & CABLE COMPANY

2919 N. Paulina St. Chicago 13, Ill.

Branches: Los Angeles—Houston—Denver

DON'T FORGET

the box number when answering advertisements. It is the only way we can identify the advertiser to whom you are writing.

ADDRESS BOX NO. REPLIES TO: Box No. Classified Adv. Div. of this publication. Send to office nearest you.

NEW YORK 36: P. O. BOX 12

CHICAGO 11: 520 N. Michigan Ave.

SAN FRANCISCO 4: 68 Post St.

BUSINESS OPPORTUNITIES

Wanted: To buy one-half interest in an electrical contracting or motor repairing shop in mid-west area. BO-1328, Electrical Construction & Maintenance.

Electrical Estimator wanted for fast growing contracting firm in Southern California. BO-1533, Electrical Construction & Maintenance, San Francisco.

continued from page 377

Sticht Co., Inc. Herman H.... 359
Stromberg-Carlson Co. 319
Stromberg Time Corp..... 90
Sylvania Electric Products Inc. 88, 236

T

Thermoid Div., H. K. Porter Company, Inc. 296
• Thiel Tool & Engineering Co.. 357
• Thomas & Betts Co., The..... 260
Thompson Electric Co., The... 311
• Triangle Conduit & Cable Co., Inc. 97, 99

U

Union Metal Mfg. Co., The.... 16
• United States Rubber Co..... 200
Universal Motor Co..... 371
Up-Right Scaffolds 86
Uptegraff Mfg. Co., R. E. 22, 23
Utica Drop Forge & Tool Div., Kelsey Hayes Co..... 84
Utility Body Co..... 366
• Utility Transformer & Equipment Co. 373

V

• Velocity-Power Tool Co..... 347
Vermeer Mfg. Co..... 357
Virden Co., John C..... 95

W

• Wagner Electric Corp.....184, 268
Wakefield Co., The.....249, 250
• Westinghouse Electric Corp. Pittsburgh 66, 67, 278, 279, 280, 281, 282, 283, 305, 306, 307, 308
Western Insulated Wire Co.... 317
Wheeler-Fullerton Lighting Div. 207
• Wheelock Signals Inc..... 377
Where To Buy..... 373
White-Rodgers Co. 367
Whitney Blake Co..... 210
• Wiegand Co., Edwin L..... 34
Wiley Inc., R & W..... 329
Wiremold Co., The..... 288
• Wodack Electric Tool Corp... 373

Y

• Youngstown Sheet & Tube Co., The 26

Z

• Zenith Electric Co..... 357

CLASSIFIED ADVERTISING

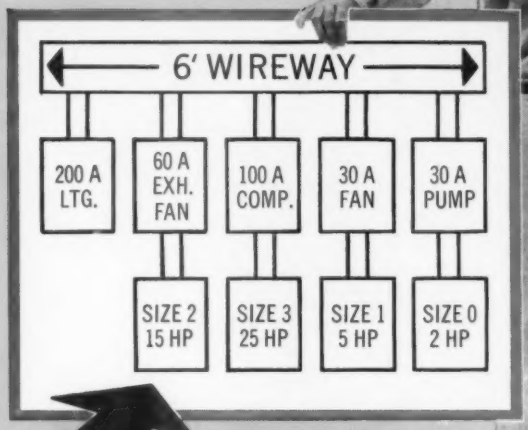
F. J. Eberle, Business Mgr.

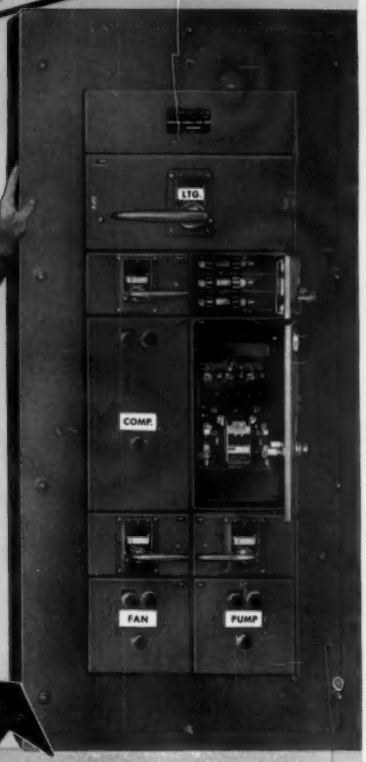
EMPLOYMENT OPPORTUNITIES... 378
SPECIAL SERVICES 378
BUSINESS OPPORTUNITIES 378
EQUIPMENT
(Used or Surplus New) For Sale 378

• These manufacturers advertised their products in the ELECTRICAL PRODUCTS GUIDE

STARTERS IN QMB PANELBOARDS!

ANOTHER SQUARE D FIRST!

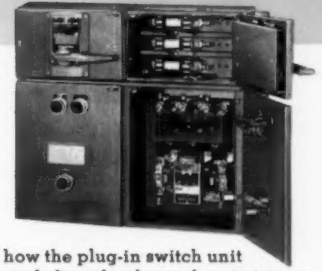




IT TAKES
41 HOURS AND 6 FEET
OF WALL SPACE TO INSTALL AND WIRE SWITCHES AND STARTERS LIKE THIS

IT TAKES
12 HOURS AND 30 INCHES
OF WALL SPACE FOR THE SAME INSTALLATION WITH A QMB STARTER PANELBOARD

Why mount separate starters and disconnect switches? It costs extra money. It wastes space. It takes a lot more time. QMB Starter Panelboards give you a *safer* installation because you can't open a starter when the switch is ON. They give you a much *better looking* job. Since they can even be *flush* mounted, they offer a lot more installation *flexibility*. QMB panelboards accommodate reversing and non-reversing starters, sizes 0 through 3. QMB switchboards and unit substations handle sizes 0 through 5. All of them are available, factory-assembled and wired. Or get enclosures, starters and plug-in switch units from your Square D distributor for on-the-job assembly.



Notice how the plug-in switch unit is mounted directly above the starter, permitting interlocking. The starter cannot be opened when the switch is in the "ON" position.

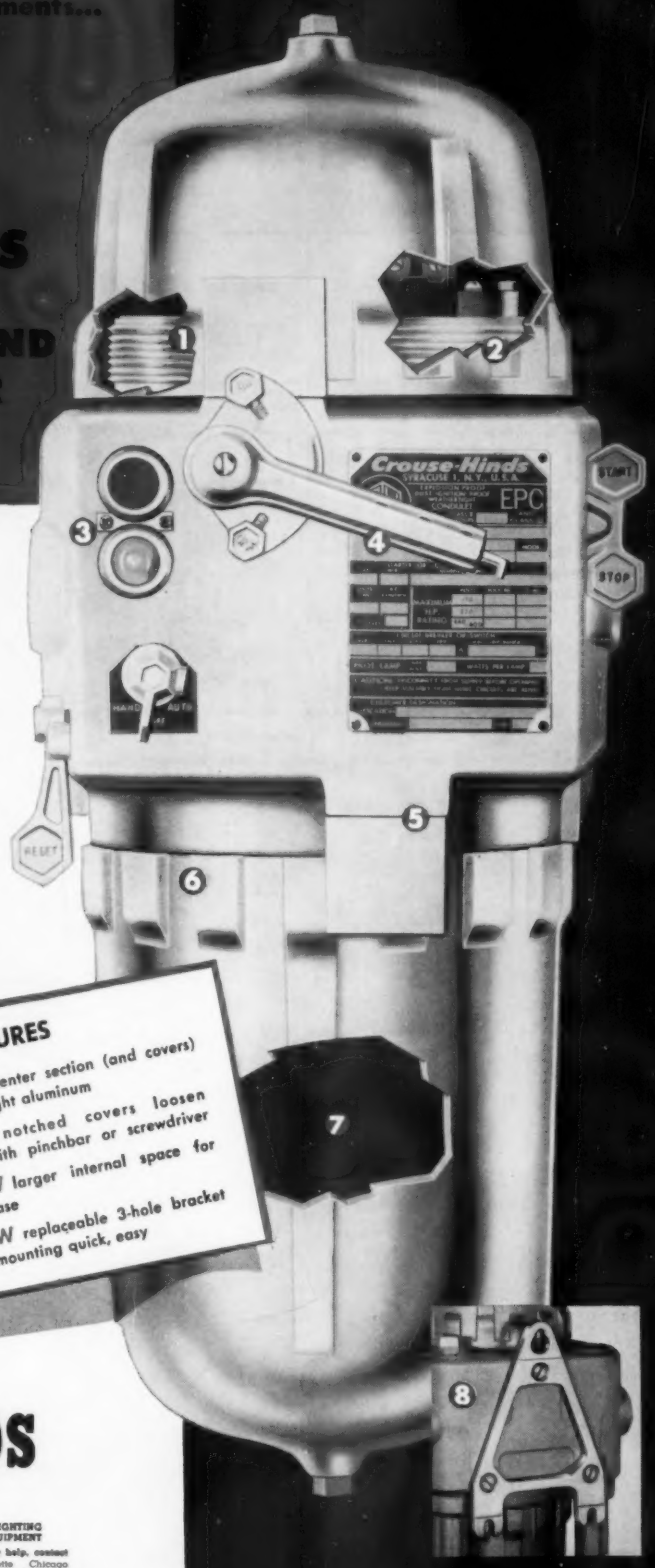
It's easy to order these starter and switch units. See Page 57 in your Square D Digest and order from your distributor.

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

Now with 8 important improvements...
at no increase in price

New EPC CROUSE-HINDS EXPLOSION-PROOF MOTOR STARTER AND CIRCUIT BREAKER



The latest refinement in a long-tested, proved and improved explosion-proof combination Motor Starter & Circuit Breaker, this new Crouse-Hinds Condulet® EPC-M59 brings you tomorrow's convenience, dependability and safety at yesterday's prices.

Designed to conform with the National Electrical Code requirements for Class I, Groups C and D; Class II, Groups E, F and G; and Class III, it provides for built-in breathers and drains . . . built-in push-button stations, selector switch and pilot lights . . . seven taper-tapped conduit entrances . . . starter below breaker for safe, easy maintenance . . . compact design to permit a greater number of controls in any given area.

Now available in 7" and 9" sizes for Sizes 1 and 2 starter combinations. For more detailed information consult your Crouse-Hinds distributor, or any of the offices listed below.

ALL THESE NEW FEATURES

1 NEW raintight joints for both top and bottom covers

2 NEW shoes and guidance slot for easier interior assembly mounting

3 NEW built-in pilot lights available where visual indication desired

4 NEW easier-to-lock breaker handle (takes up to 3 padlocks)

5 NEW center section (and covers) of lightweight aluminum

6 NEW notched covers loosen quickly with pinchbar or screwdriver

7 NEW larger internal space for wiring ease

8 NEW replaceable 3-hole bracket makes mounting quick, easy

CROUSE HINDS

MAIN OFFICE AND FACTORY: SYRACUSE, NEW YORK
Crouse-Hinds Company of Canada, Ltd., Toronto, Ont
Crouse-Hinds Instrument Company, Inc., Silver Spring, Maryland

● CONDULET® ELECTRICAL EQUIPMENT (Explosion-Proof and Conventional) ● FLOODLIGHTING
● TRAFFIC CONTROL SYSTEMS ● AIRPORT LIGHTING and WEATHER MEASURING EQUIPMENT

These products are sold exclusively through electrical distributors. For application engineering help, contact one of the following offices: Atlanta Baton Rouge Birmingham Boston Buffalo Charlotte Chicago Cincinnati Cleveland Corpus Christi Dallas Denver Detroit Houston Indianapolis Kansas City Los Angeles Milwaukee New Orleans New York Omaha Philadelphia Pittsburgh Portland, Ore. St. Louis St. Paul Salt Lake City San Francisco Seattle Tulsa Washington
Resident Representatives: Albany Baltimore Reading, Pa. Richmond, Va.